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DEGAUSSING MANUAL

BUREAU OF SHIPS
NAVY DEPARTMENT

NAVSHIPS 250-660-34

DEGAUSSING MANUAL

BUREAU OF SHIPS
NAVY DEPARTMENT

NAVY DEPARTMENT,
BUREAU OF SHIPS,
10 October 1951.

1. Degaussing our naval and merchant vessels requires the services of men engaged in at least three different types of activity; namely,

a. The operation and maintenance of deperming stations and magnetic ranges.

b. The design, installation, testing, periodic inspection, and repair of degaussing systems.

c. The operation and maintenance of degaussing systems on operating vessels.

2. Manuals prepared by the Bureau of Ordnance provide information for those engaged in the first type of activity. The Bureau of Ships Manual, Chapter 81, Section III, provides instructions for those engaged in the third type of activity.

3. This manual, the DEGAUSSING MANUAL, is for the guidance of those who are engaged in the second type of activity, the men who design and install degaussing systems, including compass compensating equipment; who test these systems after installation to make sure that they are satisfactory; who periodically inspect the degaussing installations on naval and merchant vessels; or who make the repairs that are needed from time to time.

4. This manual supersedes the DEGAUSSING MANUAL, NAVSHIPS (660), dated 15 June 1943, revised to October 1944.

5. Additional copies of this manual can be obtained from the Bureau of Ships.

H. N. WALLIN,
Rear Admiral, USN,
Chief of Bureau.

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Chapter 1

GENERAL INFORMATION ON DEGAUSSING

1-1. REASON FOR DEGAUSSING

(1) A ship is a large magnet because magnetic material, steel, is used in its hull and machinery. It has permanent magnetization like that of a permanent bar magnet, and induced magnetization like that induced in soft iron when placed in a magnetic field. The permanent magnetization is reasonably independent of the ship's heading and its position on the earth's surface, but changes somewhat with time. The induced magnetization depends upon the ship's heading and the earth's magnetic field where the ship is located, and changes when the ship changes heading or moves to a place where the earth's magnetic field is different.

(2) Because of its permanent and induced magnetization, a ship is surrounded by a magnetic field which is strong near the ship but decreases with distance. It is this magnetic field which actuates magnetic influence devices that can be used to detect the presence of the ship. The magnetic influence devices may form part of a magnetic detector whose function is merely to detect the presence of a ship, or they may form part of the firing mechanism of a magnetic mine or torpedo and cause it to explode when a ship is near. Physical contact is not necessary to actuate magnetic influence devices. Actuation is by "action at a distance" and the distance is greater, the stronger the magnetic field of the ship and the more sensitive the magnetic influence device.

(3) The purpose of degaussing is to counteract or neutralize the magnetic field produced by the permanent and induced magnetization of a ship and thereby make the ship "magnetically invisible" insofar as practicable. This will reduce the possibility that the ship can be detected by observers searching for it with magnetic detectors and will also reduce the danger of firing a magnetic mine or torpedo. If a ship were perfectly degaussed, the magnetic field near it would be just the same as if the ship were not there and the presence of the ship could not be detected by magnetic influence devices.

1-2. HOW DEGAUSSING IS DONE

A ship can be degaussed by magnetic treatment (art. 1-3) which is carried out at degaussing stations and does not require the permanent installation of degaussing equipment on the ship, or by the installation of degaussing coils and accessory equipment on the ship (art. 1-4).

1-3. DEGAUSSING BY MAGNETIC TREATMENT

(1) *Magnetic treatment processes.* The magnetic treatments used are deperming, flashing, flash-D, and wiping. Deperming is used only for ships which are degaussed by coils. Flashing, flash-D, and wiping are used for ships which are degaussed by magnetic treatment alone and are not equipped with degaussing coils.

(a) Deperming is a large scale version of demagnetizing a watch. Its purpose, as its name implies, is to reduce permanent magnetization.

(b) Flashing is a magnetizing process which has for its purpose the production of vertical permanent magnetization which is as nearly as possible equal and opposed to the vertical induced magnetization.

(c) Flash-D is a modification of flashing which produces more stable results than either flashing or wiping, and is used in preference to them.

(d) Wiping is a magnetizing process which is carried out differently from flashing but which has the same purpose.

(2) *Effectiveness of magnetic treatment.* Since induced magnetization changes with ship's heading and position while permanent magnetization does not, the cancellation of the magnetic fields produced by permanent and induced magnetization is most complete only at a particular heading and only for a particular value of the earth's magnetic field, hence, only for the positions on the earth's surface where the earth's magnetic field has this value. When the ship changes heading or moves to a place where the earth's magnetic field is different, the cancellation is not as good and the ship is not as well degaussed. For this reason, degaussing by magnetic treatment alone is not extensively used on vessels having other than limited operating areas.

1-4. DEGAUSSING BY COILS

A ship is degaussed in this way by installing one or more degaussing coils and sending direct current through the coils to produce a magnetic field which is as nearly as possible equal and opposite to the magnetic field produced by the permanent and induced magnetization of the ship. Since the magnetic field produced by ship's induced magnetization changes with the ship's heading and position, the magnetic field produced by the degaussing coils must be changed accordingly to provide effective protection against magnetic influence devices. The magnetic field of a coil is proportional to its ampere turns, NI, the product of current in amperes and the number of turns in the coil. When the ship changes heading or position, the degaussing coil ampere turns are changed to vary the magnetic fields of the coils and thus compensate for the change in the induced magnetization of the ship.

1–5. MINIMUM REQUIREMENTS FOR A DEGAUSSING INSTALLATION

(1) Minimum requirements for a degaussing installation are:

(a) Degaussing coils.

(b) A source of direct current.

(c) Control equipment to control degaussing coil ampere turns.

(2) In addition to the above essentials, compass compensating coils are installed to neutralize the degaussing coil magnetic field at magnetic compasses so that the compasses will remain useful.

1–6. KINDS AND FUNCTIONS OF DEGAUSSING COILS

Both the permanent and induced magnetization of a ship can be resolved into three components, a vertical component, a longitudinal component, and an athwartships component. Different degaussing coils are used to neutralize these components. One or more coils may be installed depending upon the degree of perfection required of the degaussing system. The coils used are:

(1) *M coil (main coil)*. The M coil, used to compensate for the ship's vertical magnetization, consists of one or more approximately horizontal loops (see art. 1–7) of which the longest loop runs at the skin of the vessel from the bow to the stern. In most permanent installations it runs internally somewhat below the main or weather deck at various heights throughout the ship. On tankers and similar ships where it is impractical to run the M coil internally, it is run on the weather deck. Fig. 1–1 is a schematic diagram of an M coil installation with a single loop.

(2) *F and Q coils (forecastle and quarterdeck coils)*. The F coil has one or more approximately horizontal loops in the forward one-third or one-fourth of the ship, usually just below the forecastle or other uppermost forward deck. The Q coil has one or more approximately horizontal loops in the after one-third or one-fourth of the ship, usually

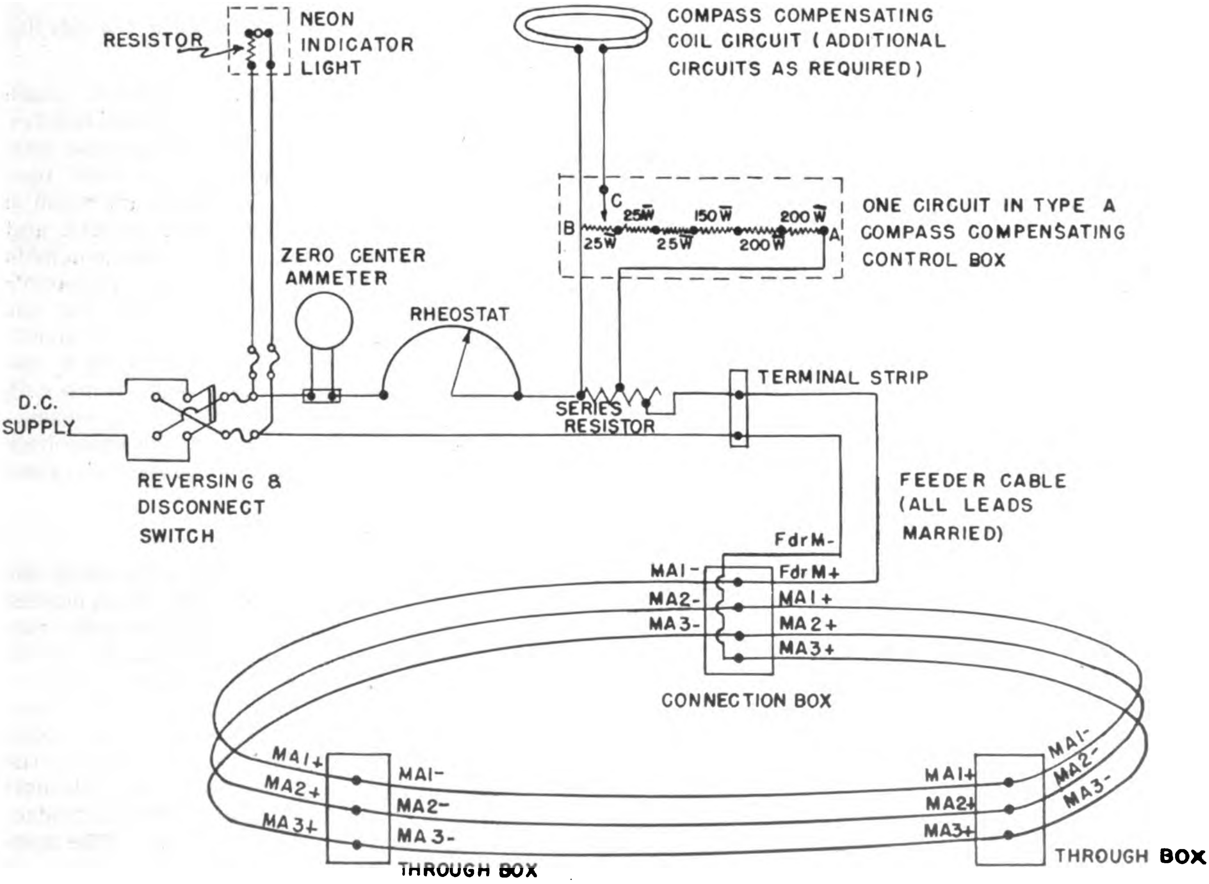

Figure 1–1. Schematic wiring diagram of an M coil degaussing installation with a single loop.

just beneath the quarterdeck or other uppermost after deck. The F and Q coils neutralize the longitudinal component of permanent and induced magnetization. Figure 1–2 is a schematic diagram of an installation with M, F, and Q coils, each coil with a single loop.

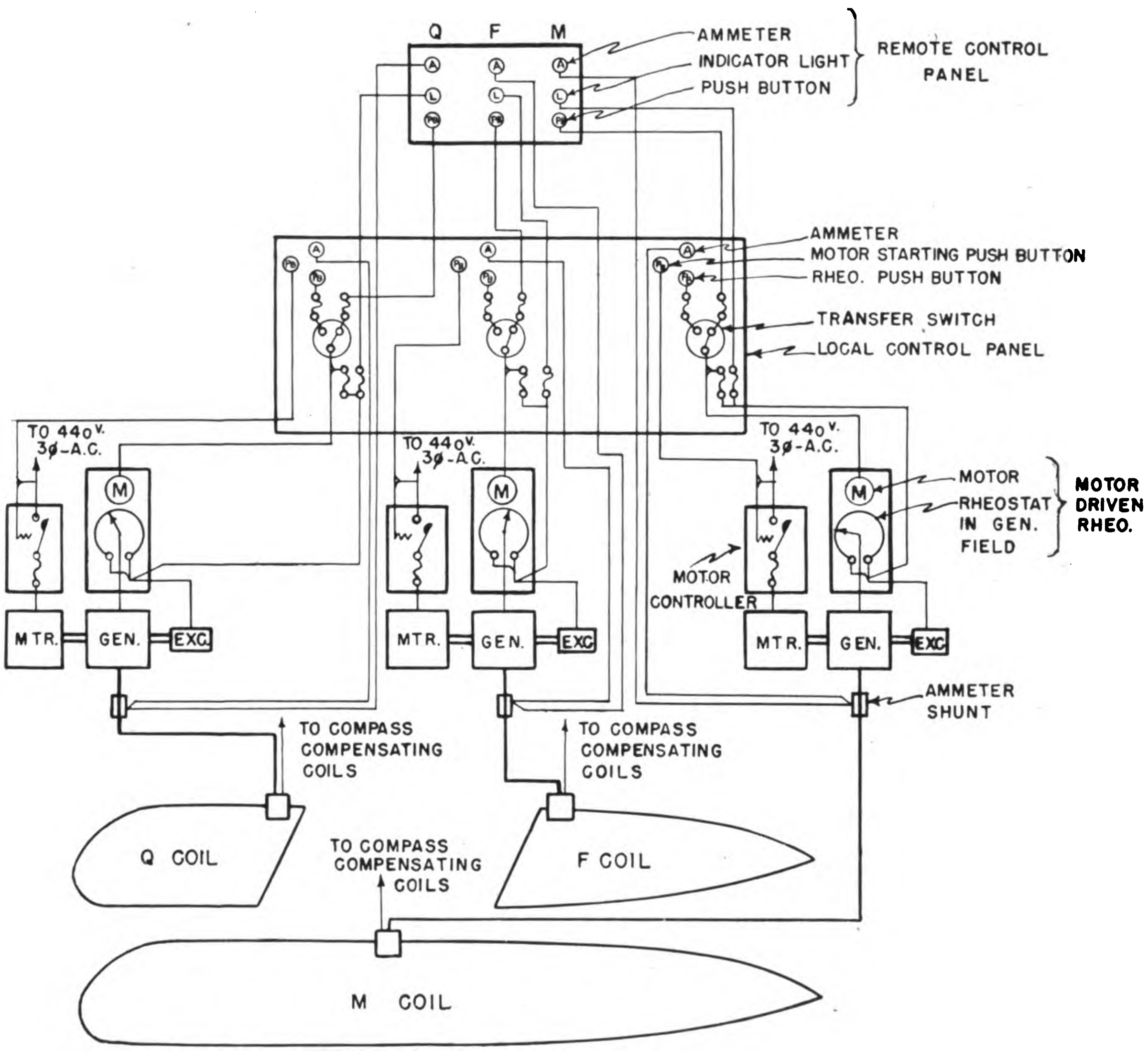

Figure 1–2. Schematic diagram of a typical M, F, and Q coil motor-generator degaussing installation.

(3) *FI, FP, QI, and QP coils.* In some installations, known as "split coil installations," the F and Q coils are each split into two coils. The FI–QI coil, which consists of the FI and QI coils connected in series, neutralizes the longitudinal component of induced magnetization; the FP–QP coil, which consists of the FP and QP coils connected in series, neutralizes the longitudinal component of permanent magnetization.

(4) *L coil (longitudinal field coil).* The L coil has loops in vertical athwartships planes. It resembles a large solenoid wound inside the ship with its axis parallel to the keel. It neutralizes the longitudinal components of permanent and induced magnetization and is sometimes used instead of F and Q coils. It gives better neutralization than F and Q coils but is not generally used because of the difficulty in installing. In some of the older installations, the longitudinal field coil is known as the S coil (solenoid coil). This designation is no longer used.

(5) *A coil (athwartships coil).* The A coil has loops in vertical fore and aft planes. It neutralizes the athwartships component of induced magnetiza-

tion. The athwartships component of permanent magnetization is small and its effect is usually neglected in A coil current settings.

(6) *MALMaux coils.* MALMaux coils have been used in many minesweepers. The MALMaux installation is made up of four independently controlled coils, M, A, L, and Maux (M auxiliary) as follows:

(a) The M coil consists of series connected horizontal loops encircling separately each of the large masses of steel in the ship having appreciable vertical extent. The M coil compensates for the vertical magnetization of these masses of steel.

(b) The A coil consists of series connected loops in longitudinal vertical planes encircling separately each of the large masses of steel in the ship having appreciable athwartships extent. The A coil compensates for the athwartships magnetization of these masses of steel.

(c) The L coil consists of series connected loops in vertical athwartships planes encircling separately each of the large masses of steel in the ship having appreciable longitudinal extent. The L coil compensates for longitudinal magnetization of these masses of steel.

(d) The Maux coil corresponds closely in design and function to the ordinary M coil and compensates the vertical magnetization which is not compensated by the M coil of the MALMaux installation. The Maux coil lies next to the skin of the vessel in an approximately horizontal plane slightly below the main deck. Maux coils have one loop running from bow to stern with or without additional shorter loops.

(7) *FL, QL, FS, and QS coils.* In place of M, F, and Q coils, several vessels have FL (forecastle, long), QL (quarterdeck, long), FS (forecastle, short) and QS (quarterdeck, short) coils. These are internal coils encircling the ship in a horizontal plane about midway between the main deck and the keel. The FL coil extends from the bow to amidships and the QL coil from amidships to the stern. The FS coil extends aft from the bow to about 15 percent of the ship's length and the QS extends from the stern forward a similar distance. Each coil is independently controlled, the FL and QL coils compensating for vertical magnetization and the FS and QS coils compensating for longitudinal magnetization. This is an early type of system and is no longer being used.

1-7. DEGAUSSING COIL LOOPS

A degaussing coil may consist of a single loop or a number of loops. Figs. 1-1 and 1-2 show single loop coils. Fig. 2-1 (in chapter 2) shows a three loop M coil and Fig. 2-2 shows three loop F and Q coils.

1-8. SINGLE CONDUCTOR AND MULTICONDUCTOR COILS

A specified number of ampere turns can be produced either by a small number of turns and a large current or by a large number of turns and a small current.

(1) *Single conductor coils.* A single conductor degaussing coil is one in which single conductor cable is used for the coil. Each loop of the coil has a small number of turns and the current is large, of the order of hundreds of amperes. Single conductor coils are usually specified for battleships, cruisers, aircraft carriers, large auxiliaries, and vessels where sufficient d-c ship's service power is not available to supply the degaussing coils.

(2) *Multiconductor coils.* A multiconductor degaussing coil is one in which multiconductor cable is used for the coil. Each loop of the coil has a considerable number of turns and the current is small, of the order of tens of amperes. Multiconductor coils are used where single conductor coils are not specified.

1-9. CONTROL OF DEGAUSSING COIL AMPERE TURNS

(1) *Control methods used.* For reasons given in art. 1-4, it is necessary to control degaussing coil ampere turns so that they can be adjusted to the values required at a particular place and heading. The following methods are used to control ampere turns:

(a) *Variable voltage.* A degaussing coil is essentially a constant resistance load. For the variable voltage method of control, the degaussing coil is connected directly to the terminals of a variable voltage generator and the generator voltage is varied to control the current through the coil. This method is always used for single conductor coils, and is also used for multiconductor coils in installations with automatic degaussing control equipment.

(b) *Variable resistance.* For this method of control, the degaussing coil in series with a reheostat is connected across a constant voltage source of power and the ampere turns are controlled by changing the rheostat setting. This method is used only with multiconductor coils, and is used extensively with them.

(c) *Variable number of turns.* For this method of control, the degaussing coil, in series with a fixed resistor, if necessary, is connected across a constant voltage power source so that a constant current flows. Ampere turns are controlled by a reversing switch which reverses one or more turns but leaves all turns connected in the circuit so that the coil resistance and coil current remain unchanged. If, for example, a loop has a total of six turns and if 0, 1, 2, 3, 4, 5, 6 turns are reversed, the ampere turns produced by the coil will be proportional to 6, 4, 2, 0, -2, -4, and -6, respectively. This method of control was used in some of the early degaussing installations but has been superseded by the variable resistance method and will not be used in future installations.

(d) *Fixed resistance control.* A few small district craft were equipped with an M coil connected to the power supply through an adjustable fixed resistor which could be adjusted by shifting links. This method is not being used for new installations.

(2) *Operator or automatic control.* The ampere turns can be set to the required value by operator or automatic control.

(a) *Operator control.* With operator control, the ampere turns for a coil are set by an operator who watches the degaussing coil ammeter and adjusts the current to the required value by manual operation of the control equipment, or by manipulation of push buttons to control electrically operated equipment such as a motor-driven rheostat, when this is installed. There is always a control station at the main degaussing switchboard. In addition, a remote control station is sometimes provided at the bridge or chart house.

(b) *Automatic control.* Current in the coils (FI–QI, A, and L) that compensate for induced magnetization must be changed as a ship changes heading or geographical position. An automatic control is being installed on some new construction and conversion vessels to vary the current for heading changes. This equipment receives a heading signal from the gyrocompass and by means of an amplifier excites either the field of a generator used to supply current for the coil, or the control winding of a magnetic amplifier used in conjunction with rectifiers to supply current to the coil. The adjustment necessary to compensate for changes in ship's position is made by an operator since ship's position changes only relatively slowly and does not necessitate frequent adjustment of degaussing coil currents.

1–10. DEGAUSSING POWER SUPPLY

Power for the degaussing coils is taken from degaussing motor-generator sets, rectifiers, or from the ship's service d-c power system.

(1) *Motor-generator sets.* The variable voltage method of ampere turn control, which is always used with single conductor installations, requires variable voltage generators to supply power to the degaussing coils. Motor-generator sets with variable voltage generators are installed for this specific purpose. Each degaussing coil which requires individual current control will need a separate generator.

(2) *Rectifiers.* Some vessels use metallic-type rectifiers for the source of degaussing power. The output of the rectifier is usually controlled by varying the a-c input to the rectifier, either by means of a magnetic amplifier, auto-transformer, or otherwise.

(3) *Ship's service power.* The variable resistance and the variable number of turns methods of controls, which are used with multiconductor installations, operate from a constant voltage power supply, hence, the ship's service d-c system can be used to supply power for the degaussing coils.

1–11. EFFECT OF DEGAUSSING ON COMPASSES AND OTHER MAGNETIC EQUIPMENT

(1) Degaussing will cause magnetic compasses to be in error if measures are not taken to compensate for changes in the ship's permanent magnetization and for the magnetic field produced by each degaussing coil. Deperming, flashing, and wiping change the permanent magnetization of a ship and necessitate readjustment of magnetic compasses. The effect of the degaussing coils is compensated by the installation of compass compensating coils. To minimize the amount of compass compensation required, it is desirable that the distance, in feet, between magnetic compasses and degaussing cables should be at least NI/200 where NI is the ampere turns of the degaussing cables.

(2) The strong magnetic field near degaussing cables may also affect gyro compasses, radar equipment, and similar equipment located near the cables. A magnetic field of about 2 gauss is to be expected at a distance of 5 feet from the cables of a coil with 1,500 ampere turns. Magnetic shielding by steel bulkheads or decks may reduce the field strength at 2 feet to about ½ what would be expected in air, but probably has no great effect upon field strength at more than 5 feet from the cables.

(3) To minimize the effect on the gyro compass, the distance, in feet, between the gyro compass and degaussing cables should be at least NI/150 where NI is the ampere turns of the degaussing coil.

(4) Degaussing may also change the centering of cathode ray tubes in radar equipment. This may be caused by changes in permanent magnetization or by magnetic fields produced by degaussing coils. Deperming usually stabilizes the ship's permanent magnetization and eliminates errors from this cause. Errors caused by degaussing coil fields are best eliminated by installing radar equipment at a distance from degaussing equipment. A magnetic field of one gauss or more may cause appreciable error in a cathode ray tube if the tube is not shielded.

(5) In general, equipment sensitive to magnetic fields should, if possible, be located far enough from degaussing cables to minimize their effect.

1–12. EFFECT OF DEGAUSSING ON ELECTRIC ARC WELDING

(1) Tests show that if the magnetic field at the arc is more than about 70 gauss, the arc is unstable and may result in an unsatisfactory weld. Smaller fields do not appreciably interfere with the arc and satisfactory welds can be made.

(2) It is impractical for welding operators to make direct measurements of magnetic field strength. They can, however, judge the strength of the field with reasonable accuracy by its effect upon

welding operations. Conditions which indicate the presence of a strong magnetic field and under which welding should not be done are as follows:

(a) The presence of serious "arc blow"(a tendency of the arc to travel away from the electrode) which makes it difficult to maintain a proper arc.

(b) A loud whine or sharp screech emitted by the welding arc.

(c) An appreciable force pulling the electrode toward the work.

(d) A tendency for the weld metal to shoot away from the arc, frequently piling up on the work without fusing properly.

(3) Where the job being done requires a steel backing up plate across the joint, or where temporary backing plates can be rigged to shunt the magnetic field away from the joint, satisfactory welding can often be done in cases which would otherwise be impossible.

(4) In general, if welding operators have no difficulty in welding when the degaussing coils are energized and if the welded joint appears satisfactory upon inspection, degaussing will have no injurious effects upon the welds. If difficulties are experienced at a particular place when the degaussing coils are energized, welding should be stopped at that place until the coils can be turned off. Otherwise the quality of the weld may be seriously injured.

1-13. MAGNETIC RANGES

A magnetic range is a station equipped to measure and record the magnetic field below ships which pass over measuring equipment located at or near the bottom of the channel in which the ships travel. A ship is said to be "ranged" when its magnetic field is measured at a magnetic range. Such measurements are used to determine the value of the coil currents which give minimum magnetic field below a ship.

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Chapter 2

POLARITY, DESIGNATION, AND MARKING OF DEGAUSSING INSTALLATIONS

Section 1—POLARITY

2-1. DIRECTION OF CURRENT FLOW

The convention used throughout this manual is that the positive direction of current flow is from the positive terminal to the negative terminal in a wire connected to a battery or d-c generator.

2-2. POLARITIES OF DEGAUSSING COILS

The polarities of degaussing coils are as follows:

(1) In the M, Maux, F, and Q coils, and the FI, FP, QI, and QP loops of the FI–QI or the FP–QP coils, positive current shall be forward on the starboard side (counterclockwise as viewed from above the coil). This can be tested by holding a degaussing polarity indicator (meter) or a small hand compass above the coil conductors. The polarity indicator dial is marked to show the direction of current flow. If this meter is not available and a compass is used, the north seeking end of the compass should point to the outside of the coil for positive current in the coil or loop.

(2) In the A coil, positive current shall be aft in the upper limb of the coil (counterclockwise as viewed from the starboard side of the coil). This can be tested by holding a degaussing polarity indicator or a compass below the upper limb. The north seeking end of the compass should point to starboard for positive current in the coil.

(3) In the L coil, positive current shall be upward on the starboard side (counterclockwise as viewed from the after side of the coil). This can be tested by holding a degaussing polarity indicator or a compass beneath the upper limb where it crosses athwartships. The north seeking end of the compass needle should point aft for positive current in the coil.

(4) The FI loops and the QI loops of an FI–QI coil shall be connected in series so that when current is positive in the FI loops, it is negative in the QI loops. The polarity of the FI–QI coil shall be the same as the polarity of the FI loops, that is, the ammeter shall indicate positive current when the FI loops are positive.

(5) The FP loops and QP loops of an FP–QP coil on a new installation shall be connected in series so that when current is positive in the FP loops, it is negative in the QP loops. If ranging the vessel shows that it is desirable to have the FP and QP loops produce fields in the same direction, they should then be reconnected. The polarity of the FP-QP coil shall be the same as the polarity of the FP loops, that is, the ammeter shall indicate positive current when the FP loops are positive.

(6) The pointer of a zero center ammeter shall deflect to the right for positive current in the coil with which the ammeter is used. The DPDT (double-pole, double-throw) heading control switch for the FI–QI coil of the split coil system (FI, FP and QI, QP) should be closed in the "North" position for positive current in the FI–QI coil. The DPDT heading control switch for the A coil should be closed in the "East" position for positive current in the A coil. The reversing switches for M, Maux, F, Q, and FP–QP coils should be closed in the upper or right hand position for positive current in these coils, in all cases where knife switches are used.

2-3. CHECK ON COMPASS USED FOR TESTING COIL POLARITY

To avoid reversing the polarity of the polarity indicator or compass magnet used in testing current direction and coil polarity as indicated in article 2–2, neither should be held too close to degaussing cables. When using, they should be brought in toward the cable from a distance until an ample reading is obtained and then not brought any closer. In addition they should be checked after each test to make sure that the magnet has not reversed.

Section 2—DESIGNATION AND MARKING

2-11. LETTERS FOR MARKING DEGAUSSING INSTALLATIONS

The letters to be used for designating and marking and their meanings are as follows:

A	athwartships coil.
AMM	ammeter.
AX	A auxiliary coil.
CC	compass compensating coil.
D	degaussing system.
F	forecastle coil to correct for permanent and induced magnetism.
FDR	feeder.

FI	F coil to correct for induced magnetism.
FP	F coil to correct for permanent magnetism.
I	FP–QP coil. Used in conjunction with feeders, compass compensating coil, and indicator light leads.
IL	indicator light.
L	longitudinal coil.
LX	L auxiliary coil.
M	main coil.
MX	Maux (main auxiliary) coil.
P	FI–QI coil.
Q	quarterdeck coil to correct for permanent and induced magnetism.
QI	Q coil to correct for induced magnetism.
QP	Q coil to correct for permanent magnetism.
SPR	spare conductor.

2-12. DESIGNATION OF LOOPS

Each of the degaussing coils may consist of one or more loops. Each loop may consist of one or more turns of cable.

(1) The number 1, when used with the M, F, or Q coil (M1, F1, Q1), or the FI, FP, QI, or QP loops of the FI–QI or FP–QP coils, shall designate the longest loop. Other loops in each coil shall be numbered in sequence 2, 3, 4, and so on from bow to stern. See figures 2-1 and 2-2.

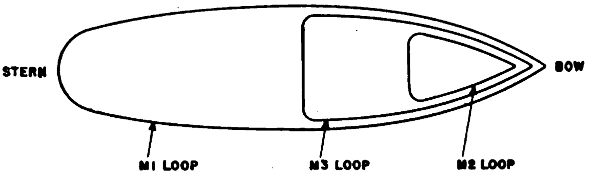

Figure 2-1. Numbering of loops for an M coil with three loops.

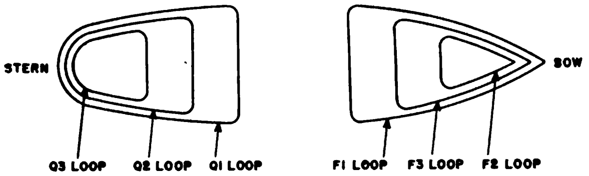

Figure 2-2. Numbering of loops for F and Q coils with three loops in each coil.

(2) The number 1, when used with the L coil (L1), shall designate the forward loop. Other loops are designated L2, L3, L4, and so on, in sequence from bow to stern.

(3) When used with the A coil (A1, A2), the numbers 1 and 2 shall designate the starboard and port loops, respectively.

2-13. DESIGNATION OF CIRCUITS

(1) Consider a degaussing coil loop consisting of one turn of 4-conductor cable. Although the degaussing cables listed in table 3-1 of chapter 3 have either only one conductor or more than four, a 4-conductor cable serves to illustrate the meaning to be attached to circuits.

(2) The four conductors in the cable can be connected as shown in figure 2-3. In this case there is only one circuit. Alternatively, the four conductors in the cable may be connected as shown in figure 2-4. In this case there are two circuits.

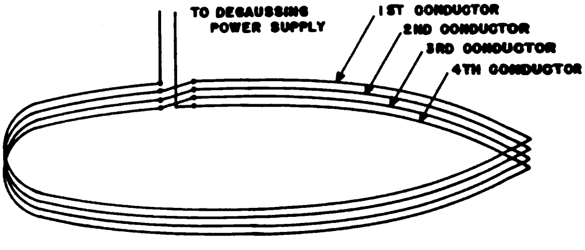

Figure 2-3. M coil with a single circuit.

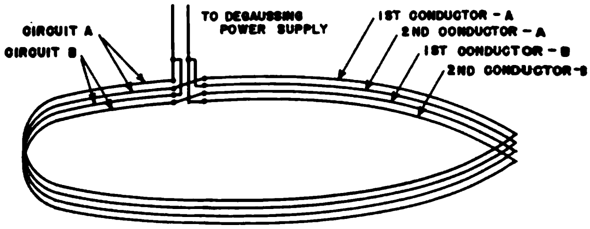

Figure 2-4. M coil with two circuits.

(3) The letters A, B, C, and so on are used as indicated in art. 2-18 (1) to designate the circuit in which a particular conductor is connected.

2-14. DESIGNATION OF DEGAUSSING COIL CABLES

(1) Degaussing coil cables shall be marked with a D for degaussing, a dash, a number 1, 2, 3, etc., to indicate the particular cable in a coil, the appropriate letter for the degaussing coil designation (M, F, etc.), a second dash, and a number to indicate the particular section of the cable, for example, D–2M–1 for the number 1 section of the number 2 cable of the M coil. A section of a degaussing coil cable is the length of cable between two successive connections or through boxes. The number designation for a cable is to be retained throughout one complete turn in a coil or loop if the cable makes a complete turn, or for as far as the cable goes if it does not make a complete turn, hence, the number designation for a *cable does not* change when the cable goes through an intermediate connection or through box, the number designation for a *section does*. Section numbers are assigned as follows:

(a) For a cable in a horizontal coil, assign section number 1 to the section which is farthest forward, and number the remaining sections in sequence going around the coil in a counterclockwise direction as viewed from above.

(b) For a cable in the A coil, assign section number 1 to the section which is highest and farthest forward, and number the remaining sections in sequence going around the coil in a counterclockwise direction as viewed from the starboard side.

(c) For a cable in the L coil, assign section number 1 to the section which is highest and farthest forward, and number the remaining cable sections in sequence going around each loop in a counterclockwise direction as viewed from the after side of the loop and going from loop to loop in the direction from fore to aft.

(d) Always include the section number in a degaussing coil cable designation even if the cable has only one section.

(2) *Examples.* (a) Each of the four cables in the FI and FP loops shown in fig. 2–5 makes a complete turn and has only one section, hence, carries section number 1, D–1FIFP–1, D–2FIFP–1, D–3FIFP–1, and D–4FIFP–1. The FIFP in the cable designation shows that the cables are used for both the FI and FP loops. A cable used exclusively for the FI or FP loops would carry the letter designation FI or FP, as the case may be.

(b) Each of the number 1, 2, and 3 cables of the QI and QP loops shown in fig. 2–5 makes a complete turn and has three sections. The number 4 cable makes only part of a turn and has only one section.

2–15. DESIGNATION OF FEEDER CABLES

(1) *Power supply cables.* Degaussing power supply feeder cables shall be marked with a D for degaussing, a dash, FDR for feeder, a letter to indicate the coil to which the feeder carries current, a second dash, and a section number. A section in a feeder cable is the length of cable between two successive items of equipment. Sections should be numbered in sequence starting from the degaussing switchboard, as D–FDRI–1, D–FDRI–2, and so on, if there are several sections, or D–FDRI–1 if there is only a single section. When two or more feeder cables run to a coil, they should be numbered as indicated for degaussing coils, for example, D–1FDRM–1 and D–2FDRM–1 for two feeder cables to the M coil (see fig. 2–5). When single conductor cables are used as feeder cables, the cable with the positive conductor (see art. 2–19 (1)) should be numbered 1; the cable with the negative conductor should be numbered 2. If more than two single conductor cables are used for the feeder to one coil, odd numbers should be used for the cables with positive conductors.

(2) *Interconnecting cables.* Interconnecting cables between FI and QI loops or FP and QP loops shall be considered as feeder cables and shall bear the designation of the loop to which they carry power. For example, the feeder cable which carries power from the degaussing switchboard to the FI–QI coil is designated D–FDRI–1, D–FDRI–2, and so on, irrespective of whether it connects to the FI loops or the QI loops. If the feeder cable for the FI–QI coil connects to the FI loops, the interconnecting cable between the FI and QI loops carries the power from the FI to the QI loops and is designated D–FDRQI–1. If, on the other hand, the feeder from the degaussing switchboard connects to the QI loops, the interconnecting cable between the FI and QI loops carries power from the QI to the FI loops and is designated D–FDRFI–1 as illustrated in fig. 2–5.

(3) *Compass compensating coil and indicator light cables.* Feeder cables for compass compensating coils or indicator lights should be designated D–FDR followed by a dash and letters to indicate the equipment to which they are connected, for example, D–FDR–CC for a compass coil feeder. Section numbers are omitted.

(4) *Examples.* See fig. 2–5.

(a) D–FDRP–1 designates the feeder cable to the FP–QP coil. In the arrangement shown in fig. 2–5, this cable runs directly from the degaussing switchboard to the coil and has only one section.

(b) D–1FDRM–1 and D–2FDRM–1 designate two feeder cables to the M coil.

(c) D–FDR–CC designates the compass coil feeder cable. The coil designation need be added only if the compass coil leads for different coils are run in separate cables. Thus, D–FDRM–CC would be the cable with compass coil leads to the M coil.

(d) D–FDR–CC–IL designates a cable used jointly for compass coils and indicator lights.

(e) D–FDRI–1, D–FDRI–2, D–FDRI–3 designate the three sections of the FI–QI feeder.

2–16. DESIGNATION AND MARKING OF OTHER CABLES

Power supply cables to the degaussing switchboard and remote control or auxiliary circuits shall be marked in accordance with Navy Department General Specifications for Machinery for Vessels of the United States Navy, Section S28–2.

2–17. DESIGNATION OF CONDUCTORS—GENERAL

Both the cable designation given in arts. 2–14 and 2–15 and the conductor designation given in arts. 2–18 and 2–19 shall be used even when the cable has only one conductor. This is because the conductor designation gives some information which the cable designation does not.

2–18. DESIGNATION OF DEGAUSSING COIL CONDUCTORS

(1) *Single conductors.* Degaussing coil conductors (except spare conductors, for which see art. 2–18 (2)), are to be marked with fiber or plastic tags with the following symbols, as applicable, in the order given:

M, F, Q, FI, etc., degaussing coil or loop.

1, 2, 3, etc., degaussing coil loop number. See art. 2–12. Omit the number if the coil has only one loop.

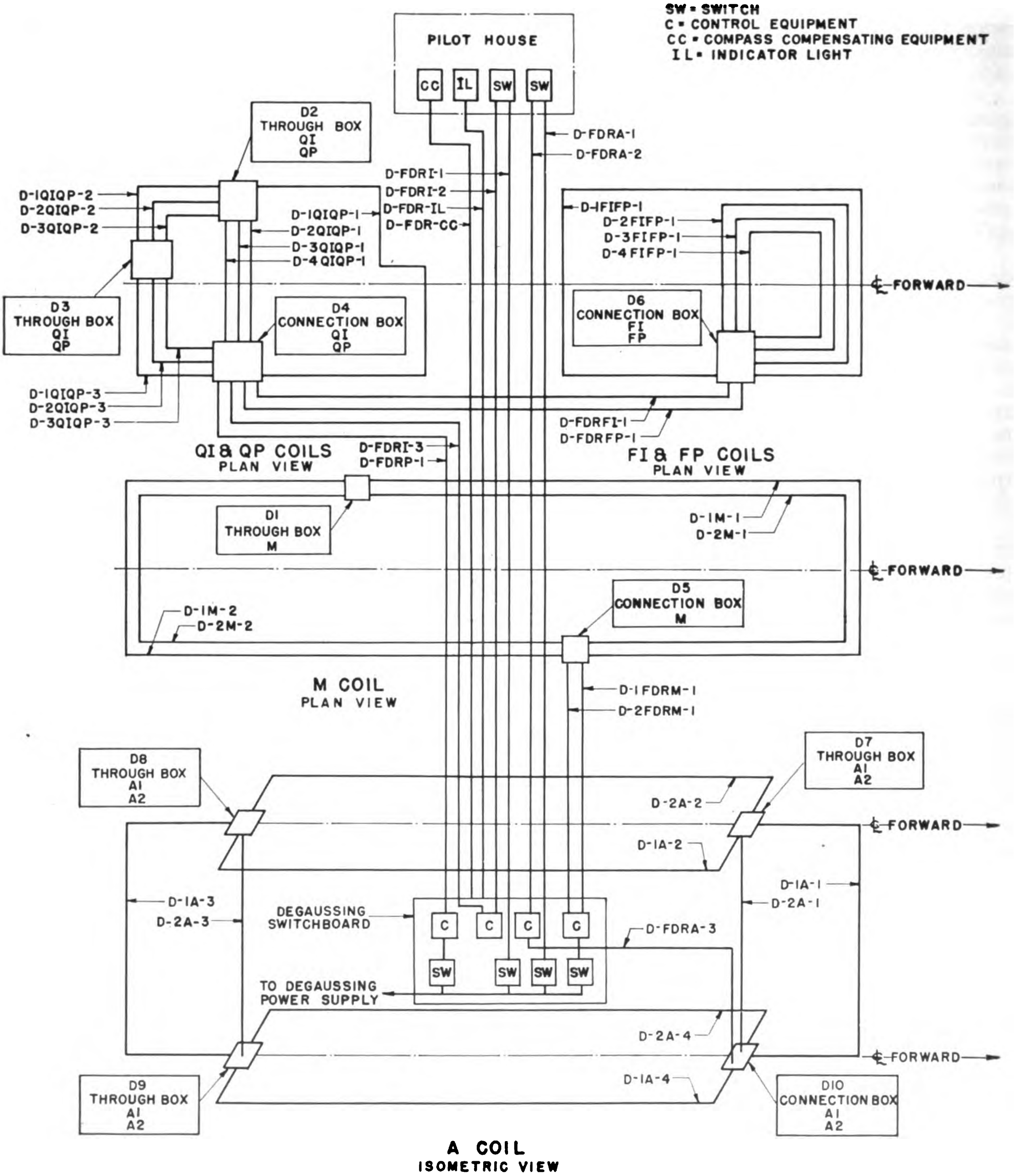

Figure 2–5. Marking scheme for degaussing coil cables, feeders, and connection and through boxes.
*Two or more conductors paralleled together within a particular series or parallel circuit receive the same conductor designation as an equivalent single conductor would receive. 12 conductor cable used for M coil.

A, B, C, etc., first, second, third circuit in the coil. See art. 2–13. Use A if there is only one circuit.

1, 2, 3, etc., first, second, third series conductor in a circuit. A conductor which is connected in a degaussing coil or loop makes a complete turn and retains the same number designation throughout the entire turn.

+ and — positive and negative geometrical polarity as follows:

(a) The ends of M, F, and Q coil and FI, FP, QI and QP loop conductors approaching a box (see art. 2–21) in the counterclockwise direction as observed from above the coil (for example, from aft for a box on the starboard side) will be positive.

(b) The ends of A coil conductors approaching a box in the counterclockwise direction as observed from the starboard side of the coil (for example, from aft for a box in the lower limb of the coil) will be positive.

(c) The ends of L coil conductors approaching a box in the counterclockwise direction as observed from the after side of the coil (for example, from below a box on the starboard side) will be positive.

(d) The conventions used for geometrical polarity, positive direction of current flow (art. 2–1), and positive direction of currents in degaussing coils (art. 2–2), are so related that *when the current in a degaussing coil is negative, the electrical and the geometrical polarities of conductor ends are the same.*

(2) *Spare conductors.* Spare conductors are to be marked with fibre or plastic tags with the same designation as for other conductors, except as follows:

(a) For a spare conductor which is available for a complete turn, omit the circuit designation, A, B, C, etc., and substitute SPR in its place.

(b) For a spare conductor which is not available for a complete turn, use the designation of the cable in which the spare conductor is contained, including the cable section number, and follow the cable designation with SPR, a number to identify the spare conductor, and + or — to indicate geometrical polarity, for example, D–3M–1SPR2+.

(3) *Paralleled conductors.* Conductors paralleled together *within a portion of* a particular series or parallel circuit and *not* constituting regular full length circuits receive the same conductor designation that equivalent single conductors would receive.

(4) *Examples.* (a) MA5— designates the M coil (single loop since the loop number is omitted), the A parallel circuit, the fifth series conductor in the circuit, and the end approaching a box in the clockwise direction as observed from above the coil. See fig. 2–6.

(b) M1B10— designates the M1 loop of the M coil, the B parallel circuit, the tenth series conductor in the circuit, and the end approaching a box in the clockwise direction as observed from above the coil.

(c) QP2A6+ designates the QP2 loop of the FP–QP coil, the A parallel circuit, the sixth series conductor in the circuit, and the end approaching

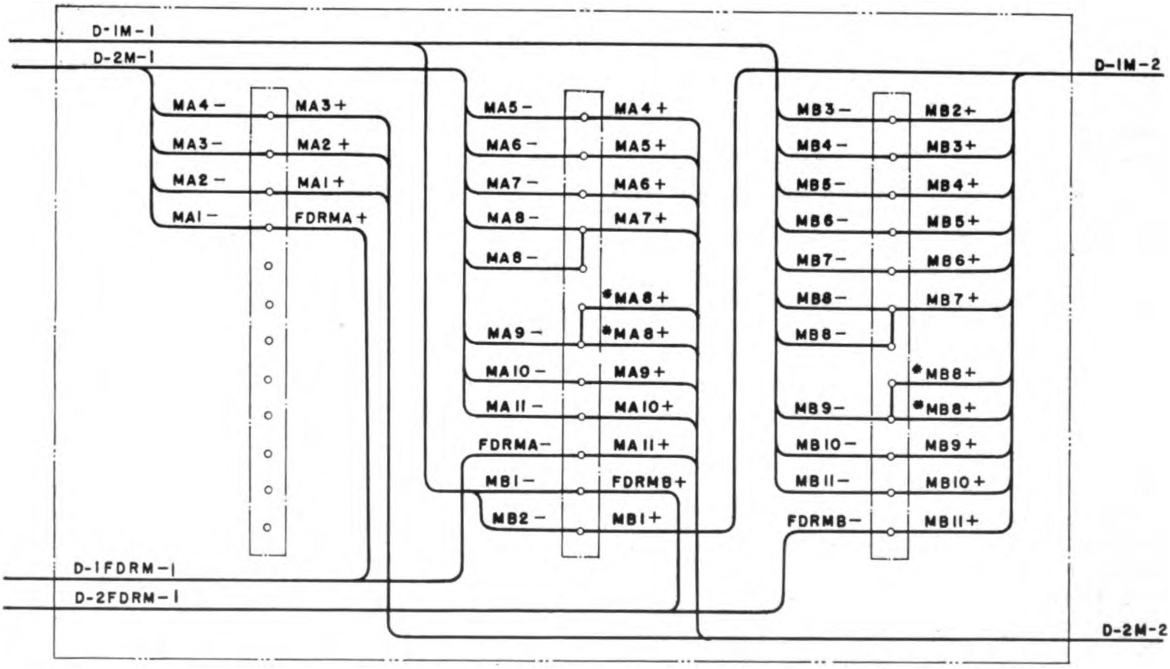

Figure 2–6. Typical single loop M coil connection box on the starboard side (box D5 of fig. 2–5) as seen looking to starboard.

a box in the counterclockwise direction as observed from above.

(d) QP2SPR2+ designates the QP2 loop of the FP–QP coil, the number 2 spare conductor, and the end approaching a box in the counterclockwise direction as viewed from above.

(e) D–4QIQP–1SPR9— designates a spare conductor which is in the number 1 section of the number 4 cable of the QI–QP coil and which is not available for a complete loop, hence, is given the cable designation. The 9 is for the ninth spare conductor, and the — is for the end approaching a box in the clockwise direction as observed from above.

2–19. DESIGNATION OF FEEDER CABLE CONDUCTORS

(1) *Power supply cables.* Conductors in cables for power supply to degaussing coils are to be designated by the following symbols, as applicable, in the order given:

FDR, feeder.

M, F, Q, FI, etc., degaussing coil or loop.

1, 2, 3, etc., coil loop number. The loop number shall be omitted if power for the entire coil is fed into one loop.

A, B, C, circuit designation. Use *only* when individual parallel circuits are fed separately, for example, where multicircuit rheostats are used.

+ and —, positive and negative electrical polarity when the controls are in the position for positive current (see art. 2–2).

(2) *Compass compensation and indicator light cables.* Conductors in compass compensating and indicator light feeder cables are to be designated with the following symbols, in the order given:

M, F, Q, I, P, A, L, etc., degaussing coil.

CC, for compass compensating coil conductors, or, IL, for indicator light conductors.

+ or —, electrical polarity when current in coil is positive.

(3) *Examples.* (a) FDRP+ designates the FP–QP coil feeder conductor which has positive electrical polarity when the controls are set for positive current in the FP–QP coil. See fig. 2–7.

(b) M–CC+ and M–CC— designate the two compass coil conductors from the M coil. See fig. 2–7.

(c) I–IL+ and I–IL— desginate the two indicator light conductors for the FI–QI coil. Polarities are marked for positive polarity in the FI coil. See fig. 2–7.

2–20. CABLE AND CONDUCTOR TAGS

(1) Cable and conductor tags on naval vessels shall conform to section S28–2 of the General Specifications for Machinery for Vessels for the United States Navy. Important requirements are that degaussing cable tags be made of metal and be colored yellow to indicate a semivital circuit, and that degaussing cables be tagged as close as practical to both sides of decks, bulkheads, or other barriers and

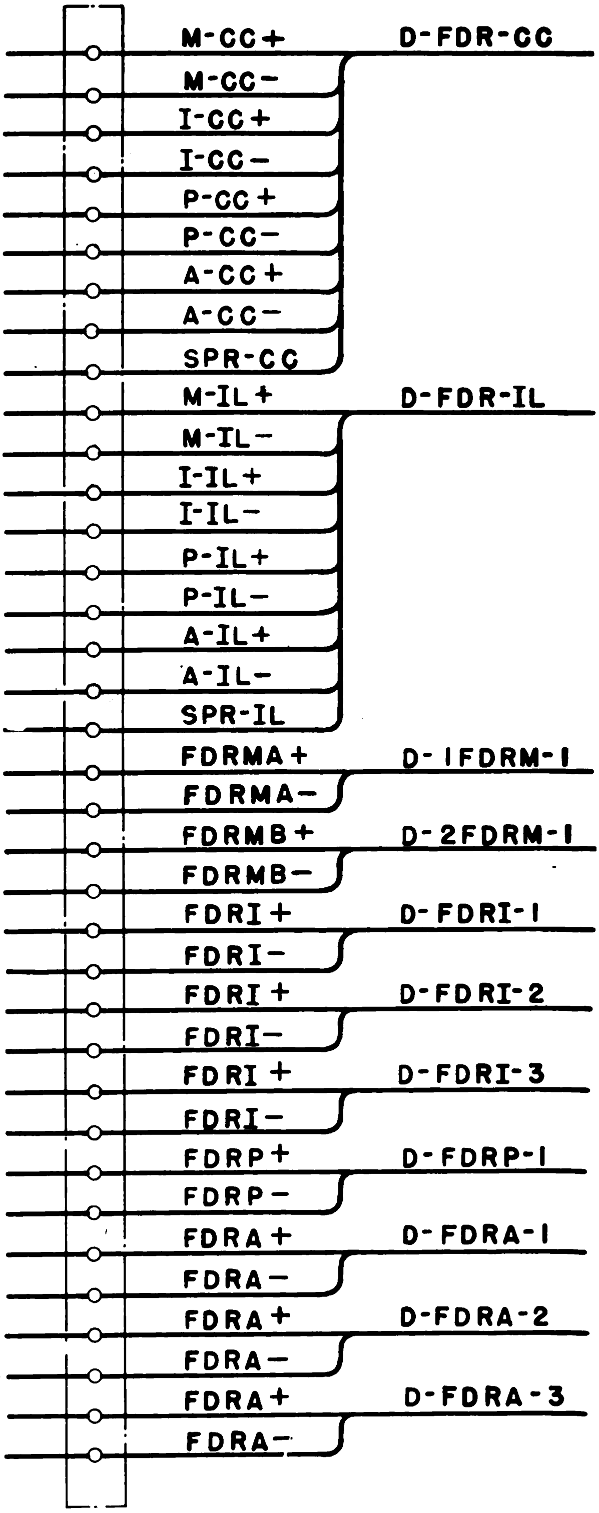

Figure 2–7. Typical degaussing switchboard connection strip.

at intervals such that the length of cable between tags does not exceed 50 feet. Conductor tags are to be made of fibre or plastic. Tags are to be rigidly attached to the cable or conductor so that the tag marking is parallel to the axis of the cable or conductor.

(2) Cable and conductor tags for merchant vessels are the same as for naval vessels.

(3) In both naval and merchant vessels, a degaussing coil conductor tag is to be fastened to each end of all conductors inside the connection or through box. Note that conductor tags are to be made of fibre or plastic, hence, are to be non-metallic and non-conducting. The use of metal conductor tags has been a source of trouble in the past.

2-21. CONNECTION AND THROUGH BOXES—DEFINITIONS

Connection and through boxes are identical in construction but differ in use.

(1) A connection box is a watertight box used to connect loops together, to connect conductors in series, to reverse turns, etc. The power supply connection for a coil and all adjustments of ampere turn ratios between loops are made within connection boxes. The power supply cable and interconnecting cable for the FI–QI and FP–QP coils terminate at connection boxes.

(2) A through box is a watertight box used to connect conductors without changing the order of conductor connections. It is used whenever it is necessary to connect sections of cable.

2-22. CONNECTION AND THROUGH BOXES—NUMBERS

(1) Connection and through boxes in the M, Maux F, Q, FI–QI, and FP–QP coils are considered to be in one group. They are numbered D1, D2, D3, etc., in sequence starting at the bow and going around the vessel in a counterclockwise direction as observed from above. See fig. 2–5.

(2) Boxes for the A coil shall receive the next higher numbers after numbers for the M, F, FI, FP, QI and QP boxes have been assigned. Numbers for the A coil boxes shall be in sequence starting with the highest forward box and continuing aft on the upper limbs of both the A1 and A2 loops, then down to and forward on the lower limbs, and then up. See fig. 2–5.

(3) Boxes for the L coil shall receive the next higher numbers after numbers for the A coil boxes have been assigned. Numbers for the L coil boxes shall be assigned in sequence starting with the highest forward box on the port side and continuing around the vessel in a counterclockwise direction as viewed from above. Boxes on the center line are to be considered to be on the port side for number assignment.

2-23. CONNECTION AND THROUGH BOXES—NAME PLATES

Connection and through boxes shall have name plates designated as follows:

D1, D2, D3, etc., degaussing box number.
Connection box and/or through box, as applicable.
M1, M2, FI1, QI1, etc., coil and loop designation.

D1

Connection box	*Through box*
M1	F1
M2	

2-24. CONNECTION AND THROUGH BOXES—WIRING DIAGRAM

A wiring diagram of the connections within a box shall be pasted on the inside of the cover of the box and shall be coated with varnish or shellac. The wiring diagram for connection boxes shall designate the conductors which may be reversed without reversing other loops; shall indicate the arrangement of parallel circuits so that equal changes can be made in all parallel circuits when such changes are required; and shall also show spare conductors. Spare conductors should be secured to connectors and should be connected to form a closed or continuous circuit when possible.

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Chapter 3

DESIGN OF DEGAUSSING COILS

Section 1—GENERAL

3–1. RESPONSIBILITY FOR DESIGN

(1) The Bureau of Ordnance is responsible for specifying the kind and number of coils to be installed, the number of loops in each coil, the location of each loop, and the number of ampere turns for each loop.

(2) The Bureau of Ships is responsible for the design of the degaussing cable and control installation including the selection of cable type and size, power supply, and control equipment to give the required ampere turns. This work is usually done at Bureau headquarters but may be delegated by the Bureau to one of its field activities when necessary.

Section 2—DEGAUSSING CABLE

3–11. TYPES AND PROPERTIES

(1) The types of cable used for degaussing, their principal uses, and their properties are given in tables 3–1 and 3–2.

(2) Types SDGA, MDGA, and MDGL are known as Navy degaussing cables and are covered by Military Specification MIL–C–915(SHIPS).

(3) Types MDGT, MDGY, and DDGT are known as merchant degaussing cables and are covered by Military Specification MIL–C–2681.

(4) Type MDGW is also known as a merchant degaussing cable and is covered by Bureau of Ships Ad Interim Specification 15C7(INT). Type MDGW has been superseded by Type MDGY and is no longer

TABLE 3–1.—*Properties of degaussing cable*

Cable	Principal use [1]	Number of conductors	Cable weight (lbs/ft)	Minimum radius of bend (inches)	Cable outside diameter (inches)	Conductor outside diameter (inches)	Conductor stranding		Conductor area, (circular mils)	Conductor resistance (ohms per 1,000 feet)[2]	Stuffing tube size
							Number	Diameter (inches)			
SDGA-400 [3]	Coils for naval vessels using motor generators.	1	1.9	10	1.270	0.742	127	0.057	413,600	0.0341	M
SDGA-500		1	2.2	10	1.360	.832	127	.064	521,600	.0271	M
SDGA-650		1	2.8	11	1.460	.936	127	.072	657,600	.0215	N
SDGA-800		1	3.5	12	1.580	1.050	127	.081	829,300	.0170	P
SDGA-1000		1	4.1	12	1.710	1.180	127	.091	1,046,000	.0135	R
SDGA-1300		1	5.1	13	1.880	1.325	127	.102	1,318,000	.0106	T
SDGA-1600		1	6.3	13	2.030	1.485	127	.114	1,662,000	.00845	T
SDGA-2000		1	7.7	14	2.240	1.670	127	.128	2,097,000	.00670	W
MDGA-19 (6)[4]	Coils for naval vessels using rheostats.	19	1.08	8.0	1.285	.092	7	.031	6,512	2.23	M
MDGA-19 (14)		19	1.80	9.5	1.520	.136	7	.045	14,340	1.000	P
MDGA-19 (23)		19	2.60	10.5	1.820	.171	7	.057	22,800	.631	S
MDGA-19 (40)		19	3.90	12.5	2.100	.226	19	.045	38,910	.368	V
MDGL-19 (6)[5]	Lower A coil runs in naval vessels.	19	2.4	8.0	1.310	.092	7	.031	6,512	2.230	M
MDGL-19 (14)		19	4.0	9.0	1.550	.136	7	.045	14,340	1.000	P
MDGT-24 (2)[6]	Coils for merchant vessels and naval auxiliaries.	24	7.2	17	2.75	.292	7	.0974	66,370	.211	AA
MDGT-30 (3)		30	7.2	17	2.75	.260	7	.0867	52,630	.267	AA
MDGT-34 (4)		34	6.7	17	2.75	.232	7	.0772	41,740	.337	AA
MDGT-91 (9)		91	6.25	17	2.75	.130	7	.0432	13,090	1.085	AA
MDGY-12 (2)[7]	Coils for tankers, naval and merchant.	12	5.5	20	2.45	.292	7	.0974	66,370	.211	Y
MDGY-15 (3)		15	5.5	20	2.45	.260	7	.0867	52,630	.267	Y
MDGY-17 (4)		17	5.5	20	2.45	.232	7	.0772	41,740	.337	Y
MDGW-12 (2)[8]	See article 3–11 (4)	12	9.5	20	2.50	.292	7	.0974	66,370	.211	Y
MDGW-15 (3)		15	9.5	20	2.50	.260	7	.0867	52,630	.267	Y
MDGW-17 (4)		17	9.5	20	2.50	.232	7	.0772	41,740	.337	Y
DDGT-17 [9]	Degaussing feeder cables, merchant and naval auxiliaries.	2	.45	5.0	.830	.146	7	.0486	16,510	.858	G
DDGT-53		2	.75	6.7	1.140	.260	7	.0867	52,630	.267	L
DDGT-105		2	1.2	8.7	1.460	.372	19	.0745	105,500	.133	N
DDGT-212		2	2.0	11.7	1.780	.530	37	.0756	211,600	.0668	S
DDGT-400		2	3.6	13.5	2.250	.729	61	.0810	400,000	.0353	W

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[1] See also articles 3–11 and 3–14.

[2] See article 3–12 for conditions for which these values apply.

[3] SDGA cable has an impervious sheath and braided metal armor.

[4] MDGA cable has an impervious sheath and braided metal armor.

[5] MDGL cable has a lead sheath and an outer protective covering of tape.

[6] MDGT cable has an impervious sheath, a covering of tape, and an outer cotton braid.

[7] MDGY cable has an impervious sheath, a covering of tape, and a galvanized steel tape armor.

[8] MDGW cable has a lead sheath and steel armor. Outside diameter over lead sheath is 1.94 inches.

[9] DDGT cable has an impervious sheath (nothing more for size 17) plus a tape covering and an outer braid for sizes larger than 17.

TABLE 3-2.—*Current carrying capacity per conductor, in amperes, for degaussing cables. See Art. 3-13.*

Cable	One cable in air Ambient temperature		Two cables in air Ambient temperature		Three or four cables in air Ambient temperature		Five to seven cables in air Ambient temperature		One cable in conduit (see note 1) or eight or more cables in air Ambient temperature	
	50° C.	40° C.	50° C.	40° C.	50° C.	40° C.	50° C.	40° C.	50° C.	40° C.
SDGA-400	550	630	522	600	495	570	470	535	440	500
SDGA-500	650	740	617	700	585	665	550	630	520	590
SDGA-650	760	870	720	830	685	785	650	740	610	700
SDGA-800	890	1,020	845	970	800	920	755	870	710	820
SDGA-1,000	1,040	1,200	990	1,140	935	1,080	885	1,020	830	960
SDGA-1,300	1,220	1,400	1,160	1,330	1,100	1,260	1,040	1,190	980	1,120
SDGA-1,600	1,400	1,600	1,330	1,520	1,260	1,440	1,190	1,360	1,120	1,280
SDGA-2,000	1,600	1,800	1,520	1,710	1,440	1,620	1,360	1,530	1,280	1,440
MDGA-19(6)	14	15.5	13.5	14.5	12.5	14	12	13	11	12.5
MDGA-19(14)	22	25	21	24	20	22.5	18.5	21	17.5	20
MDGA-19(23)	30	34	28.5	32	27	30.5	25.5	29	24	27
MDGA-19(40)	43.5	49	41.5	46.5	39	44	37	41.5	35	39
MDGL-19(6)	17	19	16.5	17.5	15	17	14.5	16	14	15
MDGL-19(14)	27	30.5	25.5	29	24	27	23	26	22.5	24
MDGT-24(2)		63		60		56		52		50
MDGT-30(3)		50		48		45		41		40
MDGT-34(4)		40		38		36		33		32
MDGT-91(9)		14.5		14		13		12		11.5
MDGY-12(2)		92		87		83		77		73
MDGY-15(3)		73		69		67		61		58
MDGY-17(4)		65		61		59		54		52
MDGW-12(2)		92		87		83		77		73
MDGW-15(3)		73		69		67		61		58
MDGW-17(4)		65		61		59		54		52
DDGT-17		47		45		42		40		38
DDGT-53		100		95		90		86		82
DDGT-105		155		147		140		133		127
DDGT-212		240		228		217		206		196
DDGT-400		360		342		325		309		294

NOTE: (1) Conduit 20 feet or more in length. If conduit is less than 20 feet in length, use the "One cable in air" rating reduced by 1 percent per foot of conduit length.

used for new installations or replacements. It is still found, however, in degaussing coils on numerous tankers and oilers which were fitted with degaussing installations in the past. Type MDGW is included in the tables because it is still found in these installations.

3-12. RESISTANCE

(1) The conductor resistances given in table 3-1 are for the following conditions:

(a) All conductors in the cable carrying rated current as given in table 3-2.

(b) For types SDGA, MDGA, and MDGL cables, an average copper temperature of 90° C. at full current rating.

(c) For types DDGT, MDGT, MDGY, and MDGW cables, an average copper temperature of 80° C. at full current rating.

(2) If cables operate at less than rated current, the conductor resistances will be less than the values given in table 3-1. Conductor resistances will be reduced in the same proportion as the conductor specific resistance, for which values are given in table 3-3. The conductor specific resistances are on the basis of circular mil area of the conductor and length of the cable in feet. Because of the twist introduced in making cables, the conductor length is slightly greater than the cable length, hence, the conductor specific resistance is slightly greater than the specific resistance of copper and is not exactly the same for all types and sizes of cable because of differences in twist. The values given in table 3-3 are averages which give sufficiently accurate results for any cable size.

TABLE 3-3.—*Cable conductor specific resistance. See art. 3-12.*

Conductor current in percent of rated current	Navy cables. See art. 3-11		Merchant cables. See art. 3-11	
	In ohms per circular mil foot	In percent	In ohms per circular mil foot	In percent
100	14.2	100	14.1	100
90	13.9	98	13.7	97
80	13.6	96	13.4	95
70	13.3	94	13.2	94
60	13.1	92	12.9	91
50	12.9	91	12.7	90
40	12.7	90	12.6	89
30	12.6	89	12.5	88
20	12.5	88	12.4	88
10	12.4	87	12.3	87
0	12.4	87	12.3	87

For example, if a Navy cable is carrying 80 percent of rated current, the conductor resistance will be 96 percent of the value given in table 3-1.

3-13. CABLE RATINGS

(1) The cable ratings or current-carrying capacities given in table 3-2 are based upon the following assumptions:

(a) The ambient temperature is 50° C. for Navy cables, types SDGA, MDGA, and MDGL; and 40° C. for merchant cables, types DDGT, MDGT, MDGY, and MDGW.

(b) Degaussing cables will not be grouped with other electric cables, and will be racked in a row or rows, if four or more degaussing cables are used, with at least one-half inch between each cable and its nearest neighbor so that air can circulate between the cables.

(2) If the above conditions are not satisfied, the cable ratings given in table 3–2 should be reduced.

3–14. SELECTION OF CABLE TYPE

(1) In selecting the type of cable to be used for the coils of a degaussing system, consideration must be given to the location of the installed cable. In general, degaussing cables are installed inside the hull and out of the weather on all types of vessels with the exception of tankers and oilers. On tankers and oilers the degaussing cable is installed on the weather deck.

(2) Types SDGA and MDGA cables are designed for installation on naval vessels where the cable will not be exposed to the weather. Type MDGL cable should be used where the cable must pass through bilges or other locations subject to moisture or oil such as the lower run of A coils.

(3) Type MDGT cable is designed for installation on merchant vessels where the cable will not be exposed to weather.

(4) Type MDGY cable is designed for exposure to weather, therefore, should be used for all weather-deck runs such as are encountered on tanker and oiler installations.

(5) Where a single conductor installation cable run is required to pass through the bilge or other location subject to moisture and oil, type MDGL cable, with all conductors in parallel, should be used for that portion of the cable run. Where a single conductor installation cable run must be located on weather exposed decks, type MDGY cable, with all conductors in parallel, should be used for that portion of the cable run.

(6) Type SDGA or HFA cable should be used for feeders on Navy installations, and type DDGT cable for feeders on merchant vessel installations.

Section 3—BASIC DESIGN CONSIDERATIONS

3–21. FUNDAMENTAL RELATIONS

Consider a coil, *not* a degaussing coil to begin with, of N turns of a copper conductor of uniform cross section throughout its length. Let L be the length per turn in feet, and A the cross section of the conductor in circular mils. The resistance of the coil in ohms is:

$$R=\frac{\rho LN}{A} \qquad (3\text{–}1)$$

where ρ is the conductor specific resistance or resistivity in ohms per circular mil foot. If I is the current in amperes, the voltage drop in the coil is:

$$e=\frac{\rho LNI}{A} \qquad (3\text{–}2)$$

The power consumed in the coil in watts is

$$P=eI=\frac{\rho LNI^2}{A} \qquad (3\text{–}3)$$

The volume of copper in the conductor in circular mil feet is V=LNA. The conductor cross section is A=V/(LN). Substituting this in equation (3–3) gives:

$$PV=\rho L^2(NI)^2 \qquad (3\text{–}4)$$

When the length per turn and the number of ampere turns are specified, the product of power required times volume of copper is fixed and can be calculated from equation (3–4). We can save copper by using more power, or we can save power by using more copper, but we must have enough of both to satisfy equation 3–4.

3–22. DESIGN OF DEGAUSSING COILS

(1) *Definitions.* A single conductor degaussing installation is one in which the degaussing coils are made with single conductor cable; a multiconductor installation is one in which the coils are made with multiconductor cable.

(2) *Formula for multiple loop coils.* For the purpose of design, a degaussing coil in either a single conductor or a multiple conductor installation can be visualized as a single, long, continuous conductor which is wound around to make the different loops. Since the loops are connected in series, the voltage, E, of the source which is to supply power to the coil must be equal to or greater than the sum of the voltage drops in all the loops. Hence, if there are three loops, for example:

$$E\geq\frac{\rho L_1(NI)_1}{A_1}+\frac{\rho L_2(NI)_2}{A_2}+\frac{\rho L_3(NI)_3}{A_3} \qquad (3\text{–}5)$$

where the subscripts indicate the different loops.

(3) *Convention on ampere turns.* Throughout this manual $(NI)_1$, $(NI)_2$, and so on, denote the ampere turns produced by the number 1 loop, the number 2 loop, and so on. Note that $(NI)_2$ is *not* equal to the ampere turns effective within a number 2 loop which is inside a number 1 and number 3 loop. In this case, the ampere turns effective within the number 2 loop will be $(NI)_1+(NI)_2+(NI)_3$. Similarly, the ampere turns effective within the area enclosed by both the number 1 and number 3 loops, but no others, will be $(NI)_1+(NI)_3$. The ampere turns effective within the area enclosed *only* by the number 1 loop will be $(NI)_1$.

(4) *Basic design formulas.* At the start of a design it is expected that the conductors will carry

rated current, hence the value of ρ used should be that given in Table 3–3 for 100% current. It is also assumed, when starting a design, that the conductor cross section is the same in all loops in a coil:

$$A=A_1=A_2=A_3 \qquad (3\text{–}6)$$

With this simplification, equation (3–5) can be written in the following two alternative forms:

$$E \geq \frac{\rho}{A}\left[L_1(NI)_1+L_2(NI)_2+L_3(NI)_3\right] \qquad (3\text{–}7)$$

$$A \geq \frac{\rho}{E}\left[L_1(NI)_1+L_2(NI)_2+L_3(NI)_3\right] \qquad (3\text{–}8)$$

These are the basic equations for the design of degaussing coils. A slight modification makes them applicable for a coil with any number of loops. When a coil has more than three loops, a similar term is added to the right hand side of both equations for each additional loop; when it has less than three, a term is dropped for each loop less than three.

3–23. CHOICE BETWEEN ALTERNATIVE DESIGNS

(1) *Several designs possible.* Several designs are possible for a specified length of turn and number of ampere turns. The choice between them is determined by consideration of power and weight. Since copper is a critical material, less cable weight is usually more important than less power, provided that sufficient power is available.

(2) *Efficiency of a design.* A degaussing coil design can be considered efficient if the copper conductors are operated not much below their rated current-carrying capacity, and if there are relatively few spare conductors left in the cables used for the coil. It would be very unusual for a design to use all conductors and operate them at rated capacity because degaussing cables are available in only a relatively small number of sizes, not in an infinite series which would permit the choice of a cable with the desired number of conductors, conductor cross section, and current-carrying capacity. If, however, the current is much below rated current, or if there are a great many spare conductors, an attempt should be made to improve the design.

Section 4—CALCULATION OF CABLE SIZE FOR SINGLE CONDUCTOR COILS

3–31. NATURE OF DESIGN PROBLEM

Power for coils in single conductor installations is supplied by motor-generator sets installed for this specific purpose. The design problem is essentially that of picking out cable of sufficient current-carrying capacity and figuring the voltage which the motor-generator set must supply.

3–32. STEPS INVOLVED IN THE DESIGN

The steps involved in designing a single conductor coil are as follows:

(1) Choose the proper types of cable for the coil and for the feeder in accordance with art. 3–14.

(2) From the ampere turns specified for the different loops by the Bureau of Ordnance, determine the number of turns in each loop and the current. If, for example, the M1 loop needs 1600 ampere turns, the M2 loop 3200, and the M3 loop 3200, the M1, M2, and M3 loops can have 1, 2, and 2 turns, respectively, and the current can be 1600 amperes; or the turns can be 2, 4, and 4 and the current 800 amperes.

(3) From table 3–2 pick a degaussing cable which has a current-carrying capacity equal to or greater than the coil current necessary to produce the ampere turns required.

(4) Compute the total length of conductor in all turns of all the loops in the coil, refer to table 3–1 to find the resistance per thousand feet for the cable size chosen, and compute the voltage drop in the coil.

(5) Pick a feeder cable size of sufficient current-carrying capacity. In some cases it may be necessary to use two or more feeder cables in parallel.

(6) From the feeder cable conductor length, the resistance of the feeder cable conductor per 1,000 feet, and the current, compute the voltage drop in the feeder cable. Note that for double-conductor feeder cables the length of the feeder conductors is twice the length of the feeder cable.

(7) The sum of the voltage drops found in steps (4) and (6) is the voltage which must be available to supply the coil. This gives the voltage rating for the motor-generator set to supply power to the degaussing coil. The current rating is the current found in step (2).

3–33. COMMENTS ON PRECEDING STEPS

Expressed in terms of equation (3–7), steps (3) and (4) amount to picking a conductor cross section, A, large enough to carry the necessary current and then using equation (3–7) to find the voltage. It is more convenient, however, to follow the procedure in steps (3) and (4) than to use the equation.

3–34. EXAMPLE

(1) *Statement of problem.* Select the cable type and size and the power supply for a single conductor M coil with three loops of ampere turns and lengths as follows:

Loop	Ampere turns	Length per turn (feet)
M1	1,600	1,730
M2	3,200	120
M3	3,200	470

(2) *Solution.* (a) Type SDGA cable will be used for the single conductor installation. Start out by

assuming that the turns in the three loops are 1, 2, and 2, and the current is 1,600 amperes. There will be 5 cables where the M1, M2, and M3 loops run side by side. Reference to table 3–2 shows that none of the SDGA cables has a current-carrying capacity of 1,600 amperes for 5 cables in air.

(b) Next try 2, 4, and 4 turns and 800 amperes. There will be 10 cables where the three loops run side by side. Reference to table 3–2 shows that SDGA–1000 has a current-carrying capacity of 830 amperes for eight or more cables in air, hence, it will be large enough. The total length is $2\times1730+4\times120+4\times470=5{,}820$ feet. The resistance of SDGA–1,000 is 0.0135 ohms per thousand feet, hence, the resistance of the M coil is 0.0785 ohms. The voltage drop in the coil for 800 amperes is 62.8 volts. Add to this the voltage drop in the feeder cable which is chosen, and the result is the voltage which the motor-generator set must supply. The current it must supply is 800 amperes.

Section 5—CALCULATION OF CABLE SIZE FOR MULTICONDUCTOR COILS

3–41. NATURE OF THE DESIGN PROBLEM

(1) *General.* Multiconductor coils take their power from the ship's service direct-current system. The voltage available at the coils is usually 120 or 240 volts minus about 10 percent to allow for voltage regulation of the generator and voltage drop in the feeder cables. For multiconductor coils the available voltage is known at the outset and the design problem is essentially that of picking a cable with conductors of low enough resistance so that the sum of the voltage drops in the degaussing coil and the series resistor for power supply to the compass compensating coils is less than the available voltage. There are two cases that need to be considered.

(a) Multiconductor coils in which the coil current is controlled by a single-circuit rheostat.

(b) Multiconductor coils in which the coil current is controlled by a multicircuit rheostat.

(2) *Coils with a single-circuit rheostat.* As its name implies, a single-circuit rheostat has only one circuit. All the current for the coil with which the rheostat is used passes through the single circuit of the rheostat irrespective of whether the coil itself consists of only one circuit or consists of several parallel circuits. Most multiconductor coils have single circuit rheostats to control the coil current. The design of degaussing coils which are to be used with single-circuit rheostats is covered in arts. 3–42 to 3–46.

(3) *Coils with a multicircuit rheostat.* In a few cases a multicircuit rheostat is used to control the current in a multiconductor degaussing coil. The necessary modification of the coil design procedure is covered in arts. 3–47 and 3–48.

3–42. STEPS INVOLVED IN THE DESIGN

The procedure to be followed in designing multiconductor coils is essentially the same for coils with several loops and coils with only a single loop. The only important difference is that for multiple loop coils there will be several terms on the right hand side of equation (3–8), while for single loop coils there will be only one. The steps involved are:

(1) Select the proper type of cable in accordance with art. 3–14.

(2) For each loop multiply the length per turn by the ampere turns, and then sum the products for all loops.

(3) Find the conductor area from equation (3–8).

(4) Select a cable with a conductor of sufficient area.

(5) Divide the ampere turns for each loop by the rated current-carrying capacity of the conductor chosen. The quotients obtained usually will not be integral numbers. Round off to integral numbers as illustrated in example 1, art. 3–44. The result is the number of turns.

(6) Determine the cables required. Where several loops run side by side, use the conductors in one cable for two or more loops if possible.

3–43. REFINEMENT OF THE DESIGN

The procedure described in the preceding paragraph will lead to a design which is adequate to produce the required ampere turns, but which may have a considerable number of spare conductors. Since a good design requires that most of the conductors be used and that the conductors carry close to rated current, refinements should be attempted to see if a better solution exists. Some of the possibilities are listed below:

(1) If there is a large number of spare conductors, it may be possible to use a smaller cable by paralleling two or more conductors to obtain the necessary current-carrying capacity and circular mil area.

(2) The circular mil area determined from equation (3–8) is based upon the assumption that the cables carry rated current and that the circular mil area is the same in all parts of the coil. This raises the following possibilities:

(a) If cables operate below rated capacity, the conductor resistance will be decreased and it may be possible to use a cable with smaller conductor area than found on the basis of the initial assumption that the cables carry rated current.

(b) If parts of the circuit have a greater cross section than others because of paralleling conductors where spare conductors are available, the minimum cross section needed will be less than that given by equation (3–8). This may make it possible to use a smaller conductor cross section than the first choice. See example 2, art. 3–45.

(3) If there is a large number of spare conductors, it may be possible to increase the number of turns in each loop in proportion to the ampere turns required. This will reduce the current and power required to run the coil. In some cases it may be possible to do this without any change in the cable design; in other cases it may be necessary to add a cable in a short loop. In the latter case, a small increase in copper may result in a considerable decrease in power. See example 3, art. 3–46.

3-44. EXAMPLE 1

(1) *Statement of the problem.* Determine cable size for the FI–QI and the FP–QP coils of a split coil installation using MDGA cable. The voltage of the power supply is 120 volts and the ampere turns and lengths per turn are given in the second and third columns of the following table:

Loop	NI	Length per turn (feet)	Ampere turns times length
FI1	150	250	37,500
FI2	400	80	32,000
QI1	180	210	37,800
QI2	470	75	35,250
Total			142,550
FP1	90	250	22,500
FP2	290	80	23,200
QP1	140	210	29,400
QP2	320	75	24,000
Total			99,100

(2) *Solution.* (a) The first step is to fill in the fourth column of the preceding table. Take 110 volts for the voltage available at the coil. (See art. 3–41 (1).) From equation (3–8) find:

$$A_I \geq \frac{14.2 \times 142{,}550}{110} = 18{,}400 \text{ circular mils.}$$

$$A_P \geq \frac{14.2 \times 99{,}100}{110} = 12{,}800 \text{ circular mils.}$$

where A_I and A_P are the cross sections needed for the conductors in the I and P coils, respectively. Reference to table 3–1 shows that MDGA–19 (23) has adequate conductor cross section for the I coil and MDGA–19 (14) for the P coil.

(b) Now refer to table 3–2 for current-carrying capacity. At the bow and stern there will be a number of cables running side by side, hence take the values from the "Three or four cables in air" column, 27 amperes for MDGA–19 (23) and 20 for MDGA–19 (14).

(c) For the FI–QI coil and 27 amperes, the rating of MDGA–19 (23), the number of turns required to give the specified ampere turns for the FI1, FI2, QI1, and QI2 loops would be 5.5, 14.8, 6.7, and 17.4. Since each loop must have an integral number of turns, take 6, 16, 7 and 19 for the number of turns in the four loops. These numbers will not give exactly the ampere turns specified, but with the same current in all four loops they will give a good approximation as seen below:

Loop	N turns	I amperes	NI—Ampere turns	
			Designed	Specified
FI1	6	25.1	151	150
FI2	16	25.1	402	400
QI1	7	25.1	176	180
QI2	19	25.1	477	470

In order to match the specified ampere turns exactly, it would be necessary to use a much larger number of turns which would lead to a cumbersome design.

(d) In a similar way, the following is found for the FP loops:

Loop	N turns	I amperes	NI—Ampere turns	
			Designed	Specified
FP1	5	17.9	90	90
FP2	16	17.9	286	290
QP1	8	17.9	143	140
QP2	18	17.9	322	320

(e) A cable layout in accordance with the above is shown in figure 3–1. There are numerous spare conductors. Since the loops of the FI–QI coil have exactly the same location as the corresponding loops of the FP–QP coil, the same cable can be used for both where enough conductors are available. Furthermore, when enough conductors are available, two conductors of MDGA–19 (14) cable in parallel can be used instead of one conductor of MDGA–19

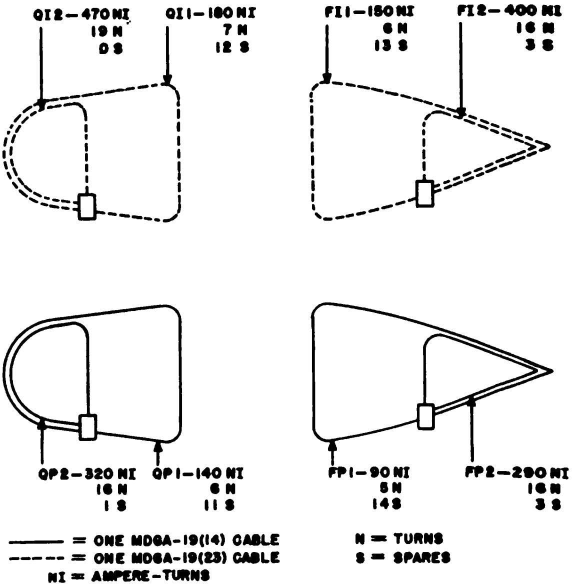

Figure 3–1. Tentative cable layout for multiconductor FI–QI and FP–QP coils. See art. 3–44.

(23) cable since they have a greater cross section and a greater current-carrying capacity.

(f) A study of figure 3–1 shows that the short (number 2) loops do not have enough spare conductors to permit the use of a single cable for both the FI2 and the FP2 loops, or for the QI1 and QP2 loops. One MDGA–19 (14) cable is sufficient, however, for both the FI1 and the FP1 loops. The FP1 loop needs 5 conductors, the FI1 loop needs 12, 6 turns with 2 conductors in parallel for each turn. This makes a total of 17 and leaves 2 spare conductors.

(g) One MDGA–19 (14) cable is not enough for both the QI1 and QP1 loops. The number of conductors needed is 8 for the QP1 loop and 2 x 7 for the QI1 loop, hence, 22 for both loops, or 3 more than the 19 conductors in the cable. We can, however, use one MDGA–19 (23) cable for both the QI1 and the QP1 loops. The final choice is shown in figure 3–2.

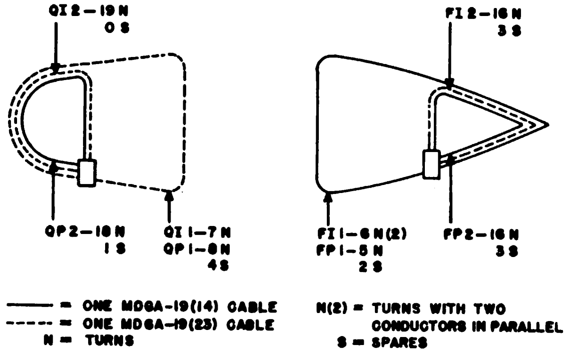

Figure 3–2. Final cable layout for multiconductor FI–QI and FP–QP coils. See art. 3–44.

(h) A check on the resistance for the arrangement shown in figure 3–2 gives 3.39 ohms for the FI–QI coil, and 4.94 ohms for the FP–QP coil. The currents in the I and P coils are 25.1 and 17.9 amperes, respectively, hence, the voltage drops will be 85.0 and 88.4 volts. Additional resistance will have to be connected in series with each coil. The added resistance will include the resistance of the feeder, the fixed resistor to provide a voltage drop for operation of the compass compensating coils, and the variable resistor installed to regulate degaussing coil current.

3–45. EXAMPLE 2

(1) *Statement of the problem.* Design an M coil with two loops, as follows:

Loop	NI ampere turns	Length per turn (feet)
M1	360	560
M2	170	190

Type MDGA cable is specified for this installation. Power is to be taken from a 240-volt ship's service system.

(2) *Solution.* (a) By following the procedure given in art. 3–42 and using 220 volts for the voltage available at the coil, it is found that the conductor cross section should be greater than or equal to 15,100 circular mils. This requires MDGA–19 (23) cable which is the smallest with the required conductor area. On the assumption, which must be checked later, that one cable will suffice for both the M1 and M2 loops where they run together, the cable rating for one cable in air can be used, 30 amperes. This gives 12 turns for the M1 loop and 6 for the M2 loop. Since the cable has 19 conductors, one cable will be enough for both loops where they run together, thus checking the original assumption that this would be the case. The cable weighs 560×2.60=1456 pounds, not counting the short length of cable needed for the M2 coil crossover. The installation produces the specified ampere turns, takes 30 amperes and hence imposes a 7.2 kw. load on the 240-volt generator, uses the cable conductors at rated capacity, uses all except one of the conductors where the M1 and M2 loops run together, but uses only 12 out of 19 conductors where the M1 loop runs alone. This suggests that a better design may be possible.

(b) Since the required conductor area, 15,100 circular mils, is not much greater than the 14,340 circular mil area of MDGA–19 (14), it is worth trying to see if a solution can be worked out with MDGA–19 (14) cable. The required ampere turns will be supplied by 18 turns in the M1 loop, 9 turns in the M2 loop, and 20 amperes, which is below the current rating for MDGA–19 (14) cable with two cables in air. With this cable size it is no longer possible to use one cable for both loops where they run together since at least 27 conductors are required, 8 more than the cable has. It will, therefore, be necessary to run another MDGA–19 (14) cable for the M2 loop. Since only 9 turns are needed for the M2 loop, each turn can consist of 2 conductors in parallel. The resistance of the two loops connected in series will then be $1.000 \times 18 \times 0.560 + (1.000/2) \times 9 \times 0.190 = 10.9$ ohms. The voltage drop for 20 amperes is 218 volts and the design can be considered satisfactory. The cable weighs $560 \times 1.80 + 190 \times 1.80 = 1{,}350$ pounds. The power required is 4.8 kw., 20 amperes from the 240-volt system. In this case, refinement of the design leads to a saving both in cable weight and power required.

3–46. EXAMPLE 3

(1) *Statement of the problem.* Find the cable size and arrangement for the FI–QI and FP–QP coils

on a merchant ship which has a 240-volt direct-current ship's service system. Loops are as follows:

Loop	NI ampere turns	Length per turn (feet)	Ampere turns times length
FI1	250	400	100,000
FI2	750	250	187,500
QI1	325	350	113,700
QI2	975	225	219,400
Total			620,600
FP1	190	400	76,000
FP2	570	250	142,500
QP1	225	350	78,800
QP2	675	225	151,900
Total			449,200

(2) *Solution.* (a) Since this is a merchant ship, the use of type MDGT cable is indicated. Size is determined by filling in the last column of the preceding table and computing:

$$A_I \geq \frac{14.1 \times 620{,}600}{220} = 39{,}800 \text{ circular mils}$$

$$A_P \geq \frac{14.1 \times 449{,}200}{220} = 28{,}800 \text{ circular mils}$$

(b) Size MDGT–34 (4) is indicated for both the FI–QI and the FP–QP coil. The current-carrying capacity is about 40 amperes. Starting with this the following results are obtained for turns and current:

Loop	N turns	Current (amperes)	NI—Ampere turns	
			Designed	Specified
FI1	7	36	252	250
FI2	21	36	756	750
QI1	9	36	324	325
QI2	27	36	972	975
FP1	6	31.9	191	190
FP2	18	31.9	574	570
QP1	7	31.9	223	225
QP2	21	31.9	670	675

(c) The total number of conductors needed for the FI1, FI2, FP1, and FP2 loop is 52, and for the QI1, QI2, QP1, and QP2 loops is 64. Since each MDGT–34 (4) cable has 34 conductors, two cables will be needed at the bow and the stern where the number 1 and 2 loops run side by side. The current is less than 38 amperes, the rating for two cables in air, hence, the choice is satisfactory from the standpoint of current-carrying capacity. A cable arrangement for the above is shown in figure 3–3. Since the cables are used at somewhat below rated capacity, the resistance of the FI–QI coil is less than 5.82 ohms and of the FP–QP coil is less than 4.74 ohms, the values obtained by using the conductor resistance for cables carrying rated current. The voltage drop is less than 210 volts for the FI–QI coil and less than 151 volts for the FP–QP coil, so that both are less than the available voltage. Hence, the arrangement shown in figure 3–3 will produce the necessary ampere turns.

(d) It is to be noted, however, that figure 3–3 shows a considerable number of spare conductors. In some parts of the coils there are enough spare conductors to permit paralleling two for each turn. Nothing is to be gained by so doing in this particular installation, however, since the resistance of the coils is already low enough and making it lower will merely increase the voltage that must be consumed in the series resistors.

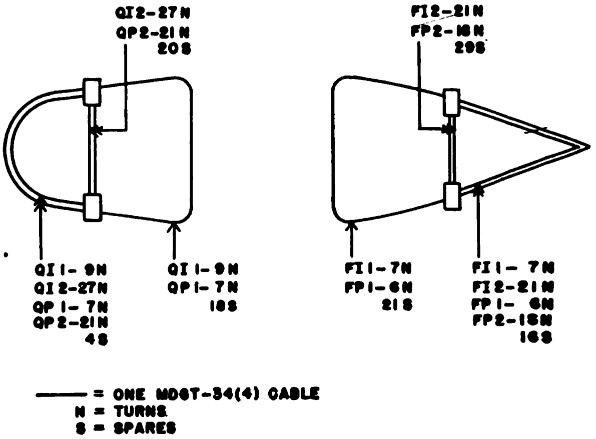

Figure 3–3. Cable layout for multiconductor FI–QI and FP–QP coils. See art. 3–46.

(e) A more promising alternative is increasing the number of turns and decreasing the current. The two cables at the bow have 68 conductors of which only 52 are used. If the turns in all loops are

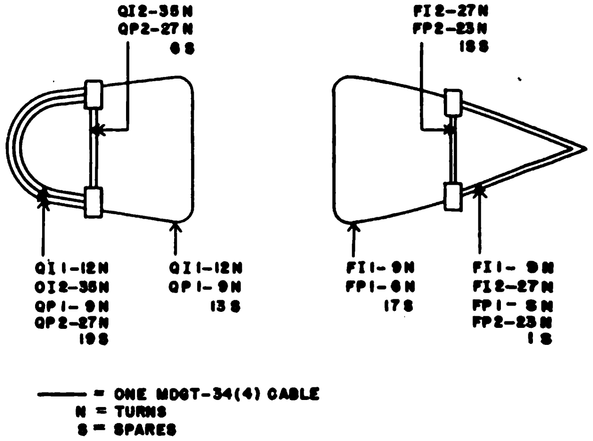

Figure 3–4. Improved cable layout for multiconductor FI–QI and FP–QP coils. See art. 3–46.

increased in the approximate ratio of 68 to 52, the result is as follows:

Loop	N turns	Current (amperes)	NI—Ampere turns	
			Designed	Specified
FI1	9	27.6	248	250
FI2	27	27.6	745	750
QI1	12	27.6	331	325
QI2	35	27.6	966	975
FP1	8	24.7	198	190
FP2	23	24.7	568	570
QP1	9	24.7	222	225
QP2	27	24.7	667	675

(f) A cable layout for the above is shown in figure 3–4. One cable has been added to a part of the Q2 coil run, but as compared to the installation in figure 3–3, the power consumption for the split F and Q coils has been reduced from 16.3 kw. to 12.5 kw. Here the addition of a relatively short length of cable results in a fairly appreciable saving in power.

(g) The voltage drops in the FI–QI and FP–QP coils are less than 209 and 151 volts, respectively.

3–47. MULTICONDUCTOR COILS WITH MULTICIRCUIT RHEOSTATS

(1) *Multicircuit rheostats.* Multicircuit rheostats for degaussing installations (see art. 4–68 (2)) are either manually-operated 4-circuit rheostats or motor-driven 2- or 3-circuit rheostats. The 4-circuit rheostat can be used for either 1, 2, 3, or 4 circuits, as required. To increase coil current, the first circuit of the coil is connected to the source of power in series with a series resistor and the rheostat. The other circuits are not connected to the source of power. Turning the rheostat handle cuts out resistance in the rheostat and causes the current to increase in the first circuit. Ultimately the rheostat resistance is all cut out and the first circuit is connected to the source of power in series with a resistor of appropriate value to limit the current to a value which is not greater than the current carrying capacity of the rheostat or the first circuit of the coil. Further rotation of the rheostat handle connects the second circuit of the degaussing coil to the power source in series with a resistor and the rheostat, cuts resistance out of the rheostat, builds up current in the second circuit, and then repeats the same cycle for each additional circuit.

(2) *Design of degaussing coils for use with a multicircuit rheostat.* Such coils must be designed with several parallel circuits. Perhaps the easiest way to pick the cable size for such coils is to calculate the conductor cross section for a *single* circuit coil to produce the required ampere turns; and then choose a cable with a conductor cross section one-half, one-third, or one-fourth the cross section calculated for the single circuit coil. This procedure is illustrated in the following example.

3–48. EXAMPLE 4

(1) *Statement of the problem.* Determine the cable size for a merchant vessel M coil which is to use a multicircuit rheostat and is to take power from a 240-volt d-c ship's service system. The ampere turns and the lengths of the loops are as follows:

Loop	NI ampere turns	Length (feet)
M1	1,450	1,250
M2	1,450	300

Calculate the conductor cross section that would be needed for a single circuit coil to produce the ampere turns, using the procedure illustrated in preceding examples. Use 14.1 for the specific resistance (see table 3–3) since this is to be a merchant vessel installation, and 220 volts for the available voltage. The result is that the conductor cross section must be equal to or greater than 144,000 circular mils. Reference to table 3–1 shows that the conductor area for MDGT–30 (3) cable is 52,630 circular mils. Three of these conductors will supply the necessary cross section, hence, a three-circuit coil is indicated. Table 3–2 shows that the current carrying capacity of a MDGT–30 (3) conductor is approximately 50 amperes. Three circuits with 50 amperes in each circuit will be equivalent to 150 amperes so that 10 turns will be needed for 1450 ampere turns, hence, the coil can consist of three circuits, each making ten turns. This will require 30 conductors, so that one MDGT–30 (3) cable can be used for the coil.

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Chapter 4

INSTALLATION OF DEGAUSSING EQUIPMENT ON NAVAL VESSELS

Section 1—GENERAL

4-1. SPECIFICATIONS

The degaussing installation on a naval vessel should conform to the following specifications:

(1). Degaussing specifications which will be issued by the Bureau of Ships for each vessel or each group of vessels to be degaussed, and which will contain detailed information on the particular installation concerned.

(2). General Specifications for Machinery for Vessels of the United States Navy. The sections which are of particular pertinence to the installation of degaussing coils are:

Section S28-2. Designating and Marking, Electrical Systems.

Section S62-2. Electric Power Distribution, Cables.

Section S62-3. Electrical Wiring Equipment, Electric System Distribution.

Section S81-6. Degaussing System.

Appendix 6. Instructions for Painting.

4-2. PLANS

The Bureau of Ships has prepared numerous plans covering methods of supporting cable, methods of sealing cable ends, mounting dimensions of equipment, electrical connections, and so on. Plans which are of pertinence to the degaussing installation are listed in chapter 11 by Bureau of Ships number and title, and copies of the plans which are of the most interest are included in chapter 11. Frequent reference should be made to them.

4-3. DEGAUSSING MANUAL

This manual contains information on degaussing systems and their installation and should be used to supplement the degaussing specifications. In case of difference between the *Degaussing Manual* and degaussing specifications, the degaussing specifications shall govern.

Section 2—CABLE

4-11. LOCATION

(1) *Importance of location.* The location of the degaussing cables determines the size and shape of the degaussing coils, hence, affects the magnetic fields they produce and influences the effectiveness of the degaussing installation. For this reason it is important that degaussing cables be installed where specified. On the other hand, degaussing specifications are based on plans which do not always show all obstructions to cable runs which may exist on a vessel. It is sometimes found that a diversion of the degaussing cables from the location specified will result in a cable run which is much easier to install and maintain. The effects of the diversion upon the effectiveness of the installation and upon the ease of installation must both be considered in arriving at the final location.

(2) *Diversions on minesweepers.* Excellent degaussing is of extreme importance in minesweepers. Every effort should be made to install the cables where specified before a diversion is considered. If it is finally decided that a diversion is imperative, specific approval of the contemplated diversion must be obtained from the Bureau of Ships or the Industrial Degaussing Group.

(3) *Diversions on vessels other than minesweepers.* Degaussing is somewhat less critical on vessels other than minesweepers and a greater possibility of diversions exists. Such diversions should be in accordance with the following:

(a) For horizontal coils (M, F, Q etc.) moving one of the sides in or out for a small distance in a horizontal plane produces a larger change in magnetic field, for the conditions usual in degaussing, than moving it up or down by the same amount. Hence, when the diversions are equal for alternate routes, the first choice should be moving vertically, the second choice moving horizontally. Whenever deviations are necessary, the area between the deviated run and the specified run is made as small as possible and the piercing of decks kept to a minimum. Moving a coil vertically from just below to just above a deck is roughly equivalent to changing its level by the height of a deck. The most important diversions of the F and Q coil runs are those which must be made on the crossover sections. When a crossover occurs at a hatch or other necessary obstruction, the crossover location is changed to just forward or just aft of the obstruction, whichever makes the smaller diversion.

(b) For a vertical coil, A coil, symmetrical diversions in both loops (port and starboard) are preferred to unsymmetrical diversions. No unsymmetrical diversion should be made which will cause a material difference in the shapes of the projections of the port and starboard loops on a longitudinal vertical plane. If, however, *small* obstacles are encountered in one loop, the loop is diverted around them without making a corresponding change in the loop on the other side of the ship. Diversions in the lower run produce a larger change in the vessel's magnetic field than similar diversions in the upper run.

(c) Where cables are specified to run just inboard the skin of a vessel, it is permissible to run the cables just inboard the frames of the vessel provided this does not place the cables more than 18 inches from the skin. The cables may be run through the webs of deep frames if ample strength compensation is made where the frames are pierced and the cables are protected from abrasion.

(d) Cable runs more than 18 inches inboard from the skin of the vessel should have the specific approval of the Bureau of Ships or the Industrial Degaussing Group.

(e) Cable runs through tanks, bilges, refrigerator spaces, hot spaces, ammunition spaces, and hazardous locations are to be avoided if possible. Diversions of a major nature may be made if they keep cables out of such locations, or if they materially decrease the time and cost of the installation, and if they do not greatly affect the effectiveness of the degaussing coils. Such diversions may involve raising a part of the M coil one deck level to pass over a fuel tank, moving an athwartships crossover of a coil to avoid an obstruction, or moving a part of a coil from above or below a deck to the other side to avoid excessive rearrangement of piping. All such diversions should be specifically approved either by the Bureau of Ships or the Industrial Degaussing Group.

4-12. APPLICABLE SPECIFICATIONS

The cable installation in degaussing systems of naval vessels should conform to the requirements of General Specifications for Machinery, Sections S62-2 and S62-3.

4-13. PRECAUTIONS WHEN INSTALLING CABLE

(1) *Pulling.* Because of the large size of degaussing cables, extra care should be observed in pulling them to avoid damage to the armor and sheath. All metal edges which might damage the cable during or after installation should be padded with a metal sleeve or plate. Note that cables are to be "walked in" and pulled only to the extent possible by the manual effort of the installation crew, that no attempt shall be made to pull the cables taut by means of chain blocks or other mechanical rigs, and that sufficient slack shall be left to allow for deflection of bulkheads without damaging the cables. See General Specifications for Machinery, Section S62-2. When severe damage to the armor occurs in pulling, it has been found desirable to replace the cable, since the damaged section may later fail.

(2) *Cold weather precautions.* The insulation and impervious sheath of degaussing cables become so brittle at temperature of 35° F. and below that they may be cracked or ruptured by handling during installation in cold weather unless special precautions are observed. Of the precautions given below, (a) is preferable; (b) next; (c) last.

(a) Heat the compartments in which the cables are to be installed to a temperature over 35° F. and handle the cable only when its temperature is above 35° F.

(b) If the temperature is below 35° F. in the compartments where cables are to be installed and it is not possible to heat the compartments, first stow the cable in a compartment heated at least to 50° F. but not above 120° F. Allow the cable to stand until the cable temperature is at least 50° F., and preferably above, then install the cable before it has cooled to 35° F.

(c) If neither of the two preceding procedures is possible, cable can be installed at 35° F. if handled very carefully. Heat the cable thoroughly where a bend is to be made by using air from portable warm air blowers. Be sure that the radius of the bend is no shorter than necessary and in no case less than the minimum radius of bend given in table 3-1. Perform all bending operations slowly at a uniform rate avoiding shocks or blows from impact.

(3) *Sealing cable ends prior to installation.* All cut ends of lengths of cables removed from reels or coils for the purpose of installation shall be sealed with an insulating compound to keep moisture from entering the cable at the ends. Unless the cable is to be installed or connected immediately, the insulating compound shall be protected by wrapping with friction tape. The cut ends of the lengths remaining on the cable reels or coils shall be sealed in accordance with BuShips plan No. 9-S-3980-L.

(4) *Sealing cable ends of installed cable.* The sealing of electrical cables on naval vessels has been established as an important factor in confining damage where such damage is accompanied by flooding of spaces or compartments. Sealing effectively prevents short circuits and fires usually resulting from water being transmitted to switchboards and other electrical equipment through electrical cables which pass into or through flooded compartments. Instructions for sealing degaussing cables are contained in section S62-2 of the General Specifications

for Machinery. BuShips plan 9–S–5357–L, which is included in chapter 11, shows the sealing method to be used.

(5) *Special precautions for MDGL cable.* (a) Type MDGL cable requires extra care during installation because the outer cable jacket consists of a soft lead sheath protected only by a layer of impregnated duck tape. The principal characteristics, including minimum radius of bend, are given in table 3–1.

(b) The principal use of type MDGL cable is for the lower parts of A coil runs which must pass through bilges or other locations exposed to water or oil. The cable should be protected by steel guard plates where it is subject to mechanical damage. Methods of installation of MDGL cable in bilges and the installation of protective plates over cable where exposed to mechanical injury are shown by BuShips plan 9–S–3980–L, sheet number 44. At both ends of the bilge run, the MDGL cable should be connected to the MDGA or SDGA cable used for the rest of the coil. Connections are to be made inside watertight connection or through boxes located in dry compartments.

(c) Cable runs with MDGL cable should be as straight as possible. Sharp edges of holes or structural members over which the cable must pass should be covered with sheet lead to protect the cable sheath. If the cable must make slight bends to clear obstructions, hardwood or metal rollers or pulleys should be temporarily bolted or welded at the bends to ease the pulling and protect the cable sheath. Trough-shaped cable guides may be used where rollers cannot be installed. A talcum base cable soap or other cable lubricant should be used at the bends and other places as necessary to ease the pulling.

4–14. CABLE SUPPORTS AND MECHANICAL PROTECTION

(1) *Cable supports.* Standard methods of securing cables are shown in BuShips plan No. 9–S–3980–L. Sheets numbered 43, 44, 45, and 46 of this plan apply to degaussing cables.

(2) *Spacing above decks.* Cables specified to run at deck level near the skin of a ship or along a bulkhead should be raised about four inches above the deck level to provide clearance for ventilation, cleaning, and painting, and should clear bulkheads by a small amount to prevent the formation of pockets in which water might collect. Where frames are bracketed to a deck, the cables may be raised to clear the brackets.

(3) *Nonwatertight bulkheads and beams.* Where cables pass through nonwatertight bulkheads or beams which are ¼ inch thick or over, no stuffing tubes shall be used, but the holes therein shall be drilled slightly larger than the cable, and the edges of the holes rounded off to prevent chafing of the cable. Where the nonwatertight bulkheads or beams are under ¼ inch in thickness, standard or special bushings as shown on BuShips plan 9–S–3980–L shall be used. On all nonwatertight bulkheads where sharp bends occur in the cables immediately after passing through such holes, standard or special bushings shall be used.

(4) *Watertight bulkheads and decks.* Where cables pass through decks and watertight bulkheads, watertight stuffing tubes and methods in accordance with Bureau standard plans shall be used.

(5) *Mechanical protection.* Cables in passageways, stowage spaces, living quarters, and other places where they are subject to mechanical damage should be protected by removable steel guard shields, similar to that shown on Bureau of Ships plan 10–T–2590–L. Care should be observed that the shields will not cause cables to become overheated and will not form pockets in which water might collect.

4–15. PASSAGE THROUGH RESTRICTED SPACES

As pointed out in article 4–11 (3) (e), the passage of degaussing cables through refrigerators, tanks, powder compartments, and chain lockers should be avoided when possible. When there is no reasonable alternative, the degaussing cables should be run through the spaces in accordance with the following instructions and Bureau of Ships plan 9–S–3980–L, sheets 43, 44, 45, and 46, which shows methods of running degaussing cables through chain lockers, hazardous locations containing combustible fluids, and spaces requiring protection for the degaussing cable.

(1) *Refrigerators.* Degaussing cables through refrigerators should be run through or outboard the insulation, preferably the latter, and should either be installed in conduit or protected as necessary by a fabricated metal enclosure.

(2) *Fuel oil tanks and storage compartments.* When degaussing cables are to be run through oil tanks or through compartments where drums or tanks containing gasoline or similar liquids are located, special approval will be required for each installation. In such cases the cable should be encased in concentric pipes. The outer pipe is to be welded securely to the tank and supported as necessary within the tank. The inner pipe is to be installed concentric with the outer pipe. The inner pipe should be of sufficient diameter to accommodate the cable and stuffing tubes which shall be fitted to each end, and shall have suitable provision for drainage. The inside diameter of the outer pipe should be such as to permit a one inch axial spacing between the outside of the inner pipe and the inside of the outer pipe. Spacers should be provided to maintain this alignment. These spacers should be arranged so that any liquid which may collect within the outer pipe will flow freely along it to the lower end. Where watertight integrity is to be observed, the space between the outer and inner pipes should be blanked off at both ends by welding plates over the

open ends. Provision for drainage of the inner and outer pipes should be made. The inner pipe can be extended beyond the outer pipe and drain plugs installed at the lower ends of both pipes. Where watertight integrity is not required, both ends of the outer pipe should be covered by rat-proofing wire; stuffing tubes should be installed on both ends of the inner pipe.

(3) *Water tanks.* Where it is necessary to run cables through water tanks, they should be enclosed in a single pipe of suitable diameter and, if required to preserve watertight integrity, should be fitted with a stuffing tube at one end. The pipe should be sloped and the cable supported on spacers clear of the lower inside surface of the enclosing pipe to provide drainage.

(4) *Powder handling and stowage compartments.* Cables passed through these areas shall be unbroken lengths; connection boxes are not to be installed within these areas. Cables should be enclosed in nonwatertight sheet metal casings of sufficient strength to prevent damage to cables. Adequate drainage should be provided for casings.

(5) *Chain lockers.* Cables through chain lockers should be in conduit and should be protected by a sheet metal enclosure.

4–16. CABLES IN WEATHER DECK INSTALLATIONS

In tanker installations it is usually necessary to run a large part of the degaussing coils on weather decks. Type MDGY cable should be used for the parts of the coils exposed to the weather. Type MDGY cable has an impervious sheath protected by steel tape armor, however, additional protection should be provided where the cable is exposed to mechanical damage at places such as chocks, bitts, winches, fueling gear, etc. Such additional protection should be fabricated from steel plate at least $\frac{3}{16}$ inch thick and mounted so as to be removable for inspection and maintenance. Cable clamps for MDGY cable should be at least 2 inches wide and ¼ inch thick spaced not more than 16 inches apart. Approximately 2 inches clearance should be maintained between the cables and the deck to permit drainage, cleaning, and painting. This clearance may be reduced when necessary to pass under obstructions.

4–17. STUFFING TUBES

(1) Sizes of stuffing tubes to be used where degaussing cables pass through watertight bulkheads are given in table 3–1. Stuffing tube dimensions and stock numbers are given on BuShips plan No. 9–S–5166–L.

(2) After stuffing tubes are packed and the gland nuts set up, the space around the cable within the gland nut of each stuffing tube, and also within the open end, shall be filled with plastic sealer electrical insulation conforming to Military Specification MIL–I–3046. See Bureau of Ships plan number 10–T–2714–L–Alt. 2 (included in chapter 11) for a drawing which shows where the plastic sealer is used.

4–18. FEEDER CABLES

(1) *Type of cable.* Navy type heat and flameproof armored (HFA) cables should be used on naval vessels for all feeders and coil connections where degaussing cables do not serve as such, except that on naval vessels where HFA cables are not in general use, other types of Navy standard cable such as DGT, may be used for feeders and coil connections.

(2) *Non-inductive runs.* All feeders and coil conductors should be run non-inductively, that is the distance between plus and minus conductors should be a minimum. If this condition is not satisfied, the feeder or coil connection cables will form another loop in the degaussing installation which may have an unexpected and highly undesirable influence upon the effectiveness of the installation. The best way to make the runs non-inductive is to use double conductor cable (DHFA or DDGT) for feeder and coil connections with one conductor positive and the other negative. If two or more cables must be paralleled to obtain the necessary current carrying capacity, one conductor in each of the cables should be positive, the other negative.

4–19. PAINTING

(1) During installation, after being pulled in but before being strapped in place, and before stuffing-tube gland nuts are tightened, steel or aluminum armored cables (other than terminal ends on backs of switchboards and panels or inside fittings and connection boxes) shall be given a thorough inspection to determine whether the factory applied paint has been damaged. Such damaged areas shall be painted with one coat of zinc chromate primer formula 84, conforming to JAN Specification JAN–P–735. Supporting structure for cable unless galvanized or zinc plated after fabrication shall be given the prime coat before installation of cable.

(2) After being secured in position, cables and supporting structure shall be painted with finish coat of surrounding compartment or with paint used for exterior surface on which cables are located.

Section 3—CONNECTION AND THROUGH BOXES

4–31. USE

(1) Unless splicing is specifically authorized, *all* connections are to be made with solderless demountable connectors mounted on terminal strips in a watertight box known as a "connection" and or "through" box. See definitions in art. 2–21. All

feeder cable or other power supply connections should be made in a connection box. Each loop of each degaussing coil should pass through a connection box. One box should be used for several loops, if possible.

(2) Through boxes can be added, where necessary to reduce the difficulty of pulling cable, but the number should be kept to a minimum.

4–32. KINDS OF BOXES

(1) Standard degaussing connection and through boxes, as shown on BuShips plans Nos. 9000–S8106–73142 to 73145, should be used whenever possible. The standard boxes provide for 1, 2, 3, or 4 twenty connector terminal strips. These boxes are known as 20, 40, 60, and 80 wire boxes. These boxes are General Stores Material bearing the following Standard Navy stock numbers:

Box size	*Stock number*
20 wire	A 17–B–32802–100
40 wire	A 17–B–32802–105
60 wire	A 17–B–32802–110
80 wire	A 17–B–32802–115

These stock numbers are for boxes only, terminal strips must be ordered separately (see art. 4–34).

(2) If a box larger than the 80-wire size is needed, two of the standard boxes can be nippled together. If a standard box cannot be used because of space limitations, a box should be made or procured incorporating the design features of the standard boxes.

4–33. LOCATION

(1) Connection boxes should be located where they permit ready access to the conductor connections since it is frequently necessary to change connections during the short time allowed for ranging a vessel. In particular, connection boxes should not be mounted so close to hot or moving equipment that a man cannot work on them while the vessel is in operation.

(2) Although both connection boxes and through boxes are to be made watertight, they should not be installed on a weatherdeck or be located in a compartment which may be flooded in normal operation of the vessel, such as the chain locker, for example.

4–34. TERMINAL STRIPS

Two types of strips are available for use with standard connection and through boxes. Both are for 20 connectors, are 23 inches long, and are shown in Bureau of Ships plan No. 9000–S8106–73142.

4–35. WIRING CONNECTION AND THROUGH BOXES

(1) Types MDGY and MDGW degaussing cables have an armor which must be removed for a distance from the end of a cable to permit packing the stuffing tube through which the cable enters a connection or through box. The method of entering types MDGY and MDGW cable into through or connection boxes is shown by Bureau of Ships plan No. 10–T–2714–L–Alt. 2, which is included in chapter 11.

(2) All conductor ends within a box shall be symmetrically arranged in numerical order on the terminal strips. If practicable, the conductors of the M1 loop should be on the terminal strip which is highest and farthest forward, and/or nearest the skin of the vessel. The conductors of other loops should be connected adjacent to the M1 loop in the following order: M2, M3 —, F1, F2 —, Q1, Q2 —, and so on.

(3) On a terminal strip which is perpendicular to the run of the cables in a degaussing coil, the connections should be made so that when the conductors are normally connected in series the current flows across the terminal strip in the same direction as in the coil.

(4) On a terminal strip so located in a box that it is parallel to the run of the cables in a degaussing coil, the geometrically positive conductor ends (see art. 2–18 (1) in M, F and Q coils should approach the terminal block connections from the top; the geometrically positive conductor ends in the A coil should approach the terminal block connections from the top or the starboard side; and the geometrically positive conductor ends in the L coil should approach the terminal block connections from the aft or outboard side.

(5) Spare conductors shall be connected to form a closed circuit when possible, that is, short circuited turns. Parallel conductors which form part of an effective turn in a circuit should be tied together and marked with the same conductor number.

(6) All conductors are to be tagged in accordance with art. 2–20.

(7) In order to facilitate later coil adjustments, the conductors should not be served with string beyond the main trunk of the cable in connection boxes.

(8) A wiring diagram of the box shall be pasted on the inside of the cover of each connection and through box and shall be coated with varnish or shellac.

4–36. DRAIN HOLES

Drain pads with pipe plugs similar to that shown on BuShips plan 9000–S8106–73142, should be installed at the low points of connection and through boxes to permit drainage of any condensate which may collect. Consideration should be given to the position of the box after installation when determining the low point for the drain plug location. To permit effective drainage the drain pad must not protrude beyond the inner surface of the box.

4–37. FILLING BOXES

Connection and through boxes should normally not be filled with filling compound. If, however, it is imperative to install a box in a damp location or in a compartment which may be flooded in normal operation of the vessel, the box should be filled with a filling compound. A filling compound suitable for boxes located in areas where the box temperature will not exceed 50° C. (122° F.) has been distributed to Naval shipyards with detailed instructions for use. This compound is known as "CARDOLITE."

Section 4—POWER SUPPLY AND CONTROL EQUIPMENT FOR SINGLE CONDUCTOR COILS

4-51. POWER SUPPLY AND METHOD OF CONTROL

Motor-generator sets with variable voltage generators are always used to supply power for single conductor degaussing coils. Degaussing coil current is varied and reversed by controlling the magnitude and direction of the generator field current, and can be set close to any desired value between plus or minus the maximum coil current (see art. 4-53 (2) (b)).

4-52. MOTOR-GENERATOR SETS

(1) *Description.* Motor-generator sets are supplied as units, either a single set or a double set. A double set consists of two generators with one driving motor. The generators normally range from 8 to 48 volts and 750 to 1,500 amperes, depending upon the requirements of the degaussing coil. Driving motors are a-c or d-c and of the right voltage to operate on the ship's service power system. If possible, all degaussing motor-generator sets on one naval vessel should be made by the same manufacturer, and should be of not more than two different ratings. Each motor-generator set must be capable of supplying any value up to and including the specified maximum positive and negative current for the degaussing coil to which it supplies power. Wiring diagrams for degaussing motor-generator sets and controls are shown by the BuShips plan 10-T-2361-L.

(2) *Location.* Factors to be considered in choosing the location of motor-generator sets are: protection afforded the sets; weight of cables; accessibility for maintenance and emergency and local operation; communication; and ventilation. If possible, the motor-generator sets should be located below the waterline and, on armored vessels, where they will be protected by the ship's armor. The sets on vessels using an L coil or FI-QI and FP-QP coils with an A and/or M coil should all be located in one compartment. The sets on vessels using F and Q coils with an A and/or M coil should all be located in one compartment, if possible, and if not possible, in not more than two compartments. The location chosen should be such as not to require leads of excessive length to any of the coils. The leads should be clipped together (if double conductor cable with one conductor positive and the other negative is not used for leads) to minimize stray magnetic effects. Most of the degaussing motor-generator sets are designed for a 50° C. ambient temperature, however, the Bureau of Ships should be consulted if it is necessary to provide additional ventilation for the motor-generator sets.

(3) *Power for motors.* When specified, both a normal and an alternate power supply must be provided for the motors of degaussing motor-generator sets. When two power supplies are provided, a manually operated transfer switch should be installed near the motor-generator set to permit selection of power from either source. If the total load connected to the transfer switch exceeds 50 horsepower, the transfer switch should be provided with an interlock so that the motor controllers will trip before the switch opens (see BuShips plan 10-T-2361-L).

(4) *Power for excitation.* Power for excitation, control, and signal purposes on ships with a-c ship's service power should be provided by an exciter integral with each motor-generator set; and on ships with d-c ship's service power should be taken from main and/or auxiliary contacts on the motor controller of each motor. The generator fields shall be completely deenergized when the motor is not running.

(5) *Connection to coil.* The generator of each motor-generator set should be connected directly to its coil without switches, circuit breakers, or fuses, except that DPST switches may be used to disconnect the coil from the generator if the generator capacity is not in excess of 200 amperes.

4-53. EQUIPMENT FOR OPERATOR CONTROL

The following equipment is needed for operator control, that is, control in which an operator sets the degaussing coil currents to the required values by manually adjusting rheostats or manipulating push buttons to control motor-operated rheostats:

(1) *Motor controller.* A motor controller is required for the motor of each motor-generator set. The controller should have overload and low voltage protection and should be of the semiautomatic type controlled by a pushbutton station near the motor-generator set. The motor controller and pushbutton station shall be in accordance with specfication MIL-C-2174 for d-c controllers and MIL-C-2212 for a-c controllers.

(2) *Motor-operated rheostat.* (a) Depending upon the excitation voltage of the generator, either a 120-volt or a 240-volt motor-operated rheostat will be used in the field circuit of each generator for controlling the degaussing coil current. Each motor-operated rheostat has two plate rheostats on a common shaft connected as shown by sheet 11 of BuShips plan 10-T-2361-L so that direction and magnitude of the generator field current can be controlled.

(b) The rheostats should control the generator current from maximum positive to maximum negative value in steps of approximately 2.5 percent of maximum current. In order to have fine control, it is necessary that the rheostat move over nearly its full range to change from maximum positive to maximum negative current. If only a small fraction of the available range is necessary, the resistance of the voltage adjusting resistor, shown by sheet 11 of BuShips plan 10–T–2361–L, should be increased, or, if necessary, a fixed resistor should be connected in series with it so that 80 to 100 percent of the available range of adjustment of the rheostat will be necessary to change the degaussing coil current from its maximum positive to its maximum negative value.

(c) The motor-operated rheostats must be capable of manual operation if motor operation fails, and must be located where they will be accessible for manual operation.

(3) *Control transfer switch.* If remote as well as local control is required, a manually operated control transfer switch must be provided at the local control station to allow pushbutton operation of the field rheostat from either the local or the remote station, leaving the other disconnected. Local operation should not be affected by blown fuses in the remote circuits. If more than one remote control station is installed, the transfer switch at the local control station shall be capable of transferring pushbutton operation to any of the control stations. Wiring diagrams of control stations are shown by BuShips plan 10–T–2361–L.

(4) *Indicator lights.* An indicator light for each motor-generator set should be installed at each remote control station to show whether the motor-generator set is or is not operating. These lights may be either filament or neon type lamps.

(5) *Ammeters.* (a) Each degaussing coil should have an ammeter at the local control station and, unless otherwise specified, at each remote control station. All ammeters are to be zero center, and of such range that maximum coil current produces a deflection of from 75 to 95 percent of full scale. The degaussing ammeters for naval vessels have a nominal scale of 250° and are capable of withstanding high impact shock. This type of deflection permits use of a longer and more readable scale in a small meter with no sacrifice in accuracy. These ammeters are shown by BuShips plan No. S8106–606016.

(b) All ammeters for one degaussing coil may be energized from a common shunt in the coil circuit or from separate shunts, preferably the latter. The leads from each ammeter should run to the shunt, that is, there should not be a common lead from the shunt branching out to the meters.

(c) After the ammeter has been installed and connected to its shunt with the necessary length of shunt leads, the instrument should be calibrated by compensating for shunt-lead resistance. A compensating wire wound spool resistor is contained in the ammeter case for this purpose. In order to compensate for the shunt lead lengths, a portion of the double resistance wire on the spool resistor should be unwound and a section shorted out with the blade of a knife or other sharp tool. The position of the knife blade should be adjusted until the proper reading is obtained by comparison with a standard ammeter. Remove the insulation from the resistance wire and twist together at the point where the knife made contact. Solder this connection and cut off the excess wire.

(d) If a standard ammeter is not available, adjustment can be made by connecting a Wheatstone bridge between one instrument terminal and one shunt lead, the other shunt lead being connected to the opposite terminal. With the shunt end of the leads connected, the bridge will measure the total resistance of the instrument and leads. In this case, the resistance spool should be adjusted until the circuit resistance is the same as the value specified on the instrument name plate.

(e) After the meter has been installed and the compensating resistor initially adjusted for correct resistance, it should not be necessary to readjust the resistor unless the shunt lead length is changed.

(f) Name plates indicating the maximum permissible current in each degaussing coil should be located near both the local and remote ammeters for the coil. This name plate should read "DO NOT EXCEED ——— AMPERES," and the value of current permissible should be that of the circuit component which has the lowest maximum current rating.

4–54. LOCATION OF CONTROL EQUIPMENT

(1) *Local station.* The generator field rheostats, motor power supply transfer switch, pushbuttons for operation of the rheostats and for starting the motors of the motor-generator sets, control transfer switch, and ammeters should be grouped to form a convenient control station near each motor-generator location selected. The ammeter for each coil should be easily readable while manually adjusting the field rheostat for the coil.

(2) *Remote stations.* Ammeters, pushbutton controls, and indicator lights should be grouped together in the pilot or chart house as specified. The location selected for the control equipment should be such that the degaussing system can be readily adjusted with each change of ship's course.

4–55. CONNECTION OF CONTROL EQUIPMENT

Bureau of Ships' drawing No. 10–T–2361–L consists of wiring diagrams for degaussing circuits with various combinations of motors, generators, and exciters, and should be followed in connecting motor-generator sets and control equipment. The compass coil leads should preferably have a separate cable, but if the installation can be simplified, it is permissible to have leads for remote ammeters and indicator lights in the same cable with the compass coil leads. Under no circumstances should a-c leads, or leads associated with a system other than degaussing, be run in the same cable with compass coil, ammeter, or indicator light leads.

4-56. AUTOMATIC DEGAUSSING CONTROL EQUIPMENT

The Automatic Degaussing Control Equipment is an electrically operated control device mounted in a cabinet on or near the degaussing switchboard. The control equipment receives an own ship's course signal from the gyro synchro transmitter and causes the degaussing coil current to vary as the cosine or sine of the magnetic heading, depending upon which is the required pattern of current variation in the degaussing coil for best degaussing protection.

Section 5—POWER SUPPLY AND CONTROL EQUIPMENT FOR MULTICONDUCTOR COILS

4-61. USE OF MULTICONDUCTOR COILS

Multiconductor coils are usually specified for degaussing coils on vessels having a 120- or 240-volt d-c power supply of sufficient capacity to provide the required ampere turns. Multiconductor coils are often specified for some of the degaussing coils on vessels on which other coils are single conductor, for example, a single conductor M coil and multiconductor FI–QI, FP–QP, and A coils.

4-62. POWER SUPPLY

Power for multiconductor coils is usually taken from the constant voltage d-c ship's service installation; occasionally from variable voltage motor-generator sets.

(1) *Ship's service power.* (a) The load factors to be used for estimating the amount of ship's service power needed for degaussing are as follows (from General Specifications for Machinery, Section S81-6):

Coil or combination of coils	*Percent of specified total power for the coil or combination of coils*
Any single coil	100
M and F; M and Q; M and L; or M and A	85
M, F, and Q; M, FI–QI, and FP–QP; L and A; F and A; or Q and A	75
M, F, Q, and A; M, FI–QI, FP–QP, and A; or M, L, and A	65

For example, consider a ship equipped with M, FI–QI, and FP–QP coils for which the specified maximum power requirements are 15, 9, and 5 kilowatts, respectively. The load factor from the table above is 75 percent. The power supply must, therefore, be able to provide $0.75\ (15+9+5)=21.75$ kilowatts for the degaussing system. The reason why the power supply is not called upon to supply the total connected load of the degaussing system, 29 kilowatts, is that the three coils are not all energized with maximum power at the same time. When the M coil needs most power, the FI–QI coil needs least, and vice versa.

(b) If the ship's service system is of sufficient capacity to handle the degaussing load in addition to the other ship's service load, no additional generator capacity need be installed; if not, the ship's service generator capacity must be increased or one or more constant voltage generators must be installed to handle the degaussing load. The installation of these is similar to that of ship's service generators and requires no further treatment here.

(2) *Motor-generator sets.* In a few cases, a motor-generator set is used to supply power for a multiconductor degaussing coil. The motor-generator sets used for multiconductor coils resemble those used for single conductor coils in that the generator voltage is varied by changing the generator field current to control the degaussing coil current; they differ in that the voltage is higher and the current lower. Only a few installations of this kind have been made to date, all of which make use of automatic degaussing control equipment (see art. 4–73) to control the generator field current.

4-63. NATURE OF AMPERE TURN CONTROL REQUIRED

The control equipment must provide for changing degaussing coil ampere turns as follows:

(1) With the exception of new construction minesweepers (MSB, AMS, and AM), M coil ampere turn requirements do not change when a vessel changes heading, but do change when the vessel changes its magnetic latitude, that is, moves to a place where the earth's magnetic field is different. Since a vessel can change its magnetic latitude at only a relatively slow rate, rapid and frequent adjustments of the M coil control are not necessary.

(2) FP–QP coil ampere turn requirements do not change when the vessel changes its heading, but they sometimes change with change in magnetic latitude due to M coil misfit. When a vessel is ranged (see art. 1–13), the FP–QP coil ampere turns are adjusted to neutralize the permanent longitudinal magnetism and are left unchanged until the vessel is ranged again, except when variation is required for changes in magnetic latitude.

(3) F, Q, FI–QI, L, and A coil ampere turn requirements change when a vessel changes either its heading or its magnetic latitude. The controls for these coils must provide for rapid adjustment of ampere turns to correct for changes in heading. Occasional adjustment is necessary to correct for changes in magnetic latitude.

4–64. COURSE CORRECTION

Changing the ampere-turns of the degaussing coils to compensate for changes in a vessel's magnetic heading is known as course correction.

(1) *Three course correction.* For three course correction, three values of ampere turns are used. With an FI–QI coil, for example, zero ampere turns are used for headings in the general direction of magnetic E or W, a positive value for headings in the general direction of magnetic N, and a negative value of equal magnitude for headings in the general direction of magnetic S.

(2) *Multiple course correction.* For multiple course correction, the 360° range of possible magnetic headings is divided into 36 intervals of 10° each, and the ampere turns are adjusted to the value for the particular interval in which the ship's magnetic heading falls.

4–65. OPERATOR AND AUTOMATIC CONTROL

In all installations, the occasional adjustment of ampere turns necessary to correct for changes in magnetic latitude is made by an operator. In most installations, the more frequent adjustment of ampere turns necessary for course correction is also made by an operator. In some installations, automatic degaussing control equipment (see art. 4–73) is used for automatic course correction.

4–66. TYPES OF CONTROL FOR MULTICONDUCTOR COILS

The types of control which are being or have been used for multiconductor coils are:

(1) *Variable resistance.* The degaussing coil, in series with a rheostat, is connected across a constant potential source of power and the rheostat is adjusted to control the degaussing coil current. This is the most commonly used control for multiconductor coils.

(2) *Variable voltage.* In some cases, motor-generator sets with variable voltage generators are used to supply power to multiconductor degaussing coils. In all such installations which have been made to date or are now contemplated, course correction is made automatically by automatic degaussing control equipment.

(3) *Variable number of turns.* In a few installations made in the past, ampere turns are controlled by reversing one or more turns while keeping the coil current constant. It is not contemplated that any further installations of this kind will be made, hence, no information on installing the control equipment is included in this manual.

4–67. CHARACTERISTICS AND INSTALLATION OF CONTROL EQUIPMENT

The information given in art. 4–68 on the characteristics and the installation of control equipment is applicable to all degaussing systems in which at least one multiconductor coil is used, and in which the multiconductor coil current is controlled by an operator who adjusts a manually or motor operated rheostat. Further details on installation of control equipment in specific types of degaussing installations are given in succeeding articles, as follows:

Type of system	*Article*
Multiconductor split F and Q coils and all other coils multiconductor	4–69
Multiconductor split F and Q coils and single conductor M coil	4–70
Multiconductor integral F and Q coils	4–71
Degaussing installations for minesweepers	4–72
Installations with automatic degaussing control equipment	4–73

4–68. ALL SYSTEMS WITH AT LEAST ONE MULTICONDUCTOR COIL

(1) *Degaussing switchboards.* The construction of degaussing switchboards should be in accordance with Military Specification MIL–S–16036 (Ships). A drip shield should be installed over the degaussing switchboard to protect equipment from oil and water from above. When the bottom of the switchboard is open, a shield should be placed under it to prevent passage of moisture and oil laden air through the equipment. The sides and rear of the switchboard should be constructed of expanded metal to permit ventilation and protect personnel.

(2) *Rheostats and resistors.* (a) A manually or motor-operated rheostat of suitable rating is required for each multiconductor degaussing coil.

(b) A resistor should be connected in series with the rheostat. The resistance of the series resistor should be such as to limit the coil current to that of the circuit component which has the lowest maximum current rating.

(c) The rheostats and series resistors should be enclosed to prevent accidental contact of operating personnel with exposed electrical parts. The operating handwheel of manually operated rheostats should project through the enclosure. The enclosure should preferably be of the expanded metal type to permit ventilation.

(d) The characteristics of degaussing rheostats and resistors are given in the following tables.

Single circuit manually-operated rheostats

Navy type	Current capacity (amperes)	Voltage	Shock rating	Standard Navy Stock No.	BuShips plan No.
5108	8	240	150	H17-R-54155-100	10-T-2544-L.
4110	10	120	150	H17-R-54151-115	10-T-2010-L.
4110A	10	120	150	H17-R-54151-100	10-T-2010-L.
4113	13	120	150	H17-R-54151-150	10-T-2010-L.
5115	15	240	150	H17-R-54155-180	10-T-2544-L.
6115	15	120	HI	H17-R-54153-125	S8106-756851.
4117	17	120	150	H17-R-54151-200	10-T-2010-L.
4123	23	120	150	H17-R-54151-250	10-T-2010-L.
4130	30	120	150	H17-R-54151-315	10-T-2010-L.
5230	30	240	150	H17-R-54155-275	10-T-2544-L.
6130	30	120	HI	H17-R-54153-250	S8106-756851.
7130	30	240	HI	H17-R-54157-250	S8106-756851.
S30B	30	120	HI	H17-R-54153-265	S8106-475153.
4240	40	120	150	H17-R-54151-375	10-T-2010-L.
6145	45	120	HI	H17-R-54153-320	S8106-756851.
S45B	45	120	HI	H17-R-54153-335	S8106-475153.
4253	53	120	150	H17-R-54151-430	10-T-2010-L.
5360	60	240	150	H17-R-54155-400	10-T-2544-L.
6260	60	120	HI	H17-R-54153-420	S8106-756851.
7260	60	240	HI	H17-R-54157-375	S8106-756851.
S60B	60	120	HI	H17-R-54153-435	S8106-475153.
4270	70	120	150	H17-R-54151-510	10-T-2010-L.
6290	90	120	HI	H17-R-54153-525	S8106-756851.
S90B	90	120	HI	H17-R-54153-540	S8106-475153.
4292	92	120	150	H17-R-54151-600	10-T-2010-L.
43120	120	120	150	H17-R-54151-700	10-T-2010-L.
53120	120	240	150	H17-R-54155-600	10-T-2544-L.
63130	130	120	HI	H17-R-54151-670	S8106-756851.
S130B	130	120	HI	H17-R-54153-685	S8106-475153.
43159	159	120	150	H17-R-54151-780	10-T-2010-L.
43210	210	120	150	H17-R-54151-850	10-T-2010-L.
43210A	210	120	HI	H17-R-54153-825	10-T-2010-L.
Multicircuit manually-operated rheostats					
1460	4×60=240	120	150	H17-R-54151-950	S8106-488342.
HI-1460	4×60=240	120	HI	H17-R-54153-950	S6202-76028.
2460	4×60=240	240	HI	H17-R-54157-850	10-T-3186-L.
Single circuit solenoid-operated rheostats					
S1-10-C	10	120	HI	H17-R-54352-100	S81-816.
S1-17-C	17	120	HI	H17-R-54352-175	S81-816.
S1-30-C	30	120	HI	H17-R-54352-300	S81-816.
Single circuit motor-driven rheostats					
S4QB	20	120	250	H17-R-54351-150	S81-0135.
S8QA	25	240	150	H17-R-54354-300	S81-0374.
S7Q	30	120	150	H17-R-54350-125	S81-0302.
S30A	30	120	HI	H17-R-54352-320	S81-0536.
S8FG	40	120	250	H17-R-54350-200	S81-0373.
S3FA	40	120	250	H17-R-54350-220	S81-053.
S3FC	40	120	250	H17-R-54351-250	S81-0202.
S4FB	40	120	250	H17-R-54351-265	S81-0135.
S8FA	40	240	250	H17-R-54354-400	S81-0373.
S8MA	40	240	150	H17-R-54354-850	S81-0372.
S3FD	45	120	250	H17-R-54350-280	S81-0126.
S45A	45	120	HI	H17-R-54352-410	S81-0537.
S45C	45	120	HI	H17-R-54352-415	S6202-3,002,155
S4MB	60	120	250	H17-R-54351-375	S81-0135.
S60A	60	120	HI	H17-R-54352-550	S81-0583.
S60C	60	120	HI	H17-R-54352-555	S6202-3,002,156
S90A	90	120	HI	H17-R-54352-700	S81-0584.
S90C	90	120	HI	H17-R-54352-705	S6202-3,002,157
S3MC	120	120	HI	H17-R-54350-710	S81-0202.
S130A	130	120	HI	H17-R-54352-900	S81-0585.

Single circuit motor-driven rheostats—Continued

Navy type	Current capacity (amperes)	Voltage	Shock rating	Standard Navy Stock No.	BuShips plan No.
S130C	130	120	HI	H17-R-54352-905	S6202-3,002,158.
S210C	210	120	HI	H17-R-54352-950	S6202-3,002,307.

Multicircuit motor-driven rheostats

Navy type	Current capacity (amperes)	Voltage	Shock rating	Standard Navy Stock No.	BuShips plan No.
S3MD	2x45	120	250	H17-R-54350-480	S81-0272
S3MA	3x40	120	250	H17-R-54350-650	S81-054

Resistors

Navy type	Current capacity (amperes)	Voltage	Resistance (ohms)	Shock rating	Standard Navy Stock No.	BuShips Plan No.
5108F	8	240	3. 0	150	H17-R-6290-80	10-T-2086-L.
4110F	10	120	6. 8	150	H17-R-6277-100	S8106-649186.
S1-10-CF	10	120	6. 0	HI	H17-R-6280-100	S81-816.
4113F	13	120	5. 9	150	H17-R-6277-130	S8106-649187.
15F	15	120-240	3. 1	HI	H17-R-6284-150	S8106-756851.
5115F	15	240	1. 6	150	H17-R-6290-150	S8106-649186.
S1-17-CF	17	120	5. 4	HI	H17-R-6280-170	S81-816.
4117F	17	120	4. 5	150	H17-R-6277-170	S8106-649186.
4123F	23	120	3. 4	150	H17-R-6277-230	S8106-649187.
4130F	30	120	2. 6	150	H17-R-6277-300	S8106-649186.
S30AF1	30	120	1. 0	HI	H17-R-6280-280	S81-643.
S30AF2	30	120	2. 0	HI	H17-R-6280-295	S81-643.
S30BF	30	120	2. 0	HI	H17-R-6280-300	S8106-475153.
S1-30-CF	30	120	3. 5	HI	H17-R-6280-305	S81-816.
30F	30	120-240	1. 6	HI	H17-R-6284-300	S8106-756851.
5230F	30	240	. 8	150	H17-R-6290-300	S8106-649186.
4240F	40	120	1. 95	150	H17-R-6277-400	S8106-649187.
S3FCF	40	120	5. 0	150	H17-R-6277-430	S81-0202.
45F1	45	120	1. 0	HI	H17-R-6277-465	S6202-30 02159.
S3FDF	45	120	3. 5	150	H17-R-6277-475	S81-0126.
S3MDF	45	120	3. 0	150	H17-R-6277-490	S81-0272.
S45BF	45	120	1. 0	HI	H17-R-6280-450	S8106-475153.
S45AF	45	120	2. 0	HI	H17-R-6280-455	S81-643.
45F	45	120-240	1. 0	HI	H17-R-6284-450	S8106-756851.
4253F	53	120	1. 48	150	H17-R-6277-530	S8106-649186.
1460F	60	120	. 5	150	H17-R-6277-600	S8106-488347.
1460G	60	120	. 5	150	H17-R-6277-601	S8106-488348.
HI-1460F	60	120	. 5	HI	H17-R-6280-600	S6202-76028.
HI-1460G	60	120	. 5	HI	H17-R-6280-601	S6202-76028.
S60BF	60	120	1. 0	HI	H17-R-6280-605	S8106-475153.
60F	60	120-240	. 82	HI	H17-R-6284-600	S8106-756851.
5360F	60	240	. 4	150	H17-R-6290-600	S8106-649186.
2460F	60	240	1. 0	HI	H17-R-6293-600	10T-3186-L.
4270F	70	120	1. 11	150	H17-R-6277-700	S8106-649187.
90F1	90	120	. 5	HI	H17-R-6277-875	S6202-3002159.
S90BF	90	120	. 5	HI	H17-R-6280-900	S8106-475153.
90F	90	120-240	. 5	HI	H17-R-6284-900	S8106-756851.
4292F	92	120	. 84	150	H17-R-6277-920	S8106-649186.
43120F	120	120	. 58	150	H17-R-6278-200	S8106-649186.
S3MCF	120	120	3. 5	150	H17-R-6277-415	S81-0202.
53120F	120	240	. 2	150	H17-R-6291-200	S8106-649186.
130F1	130	120	. 36	HI	H17-R-6278-250	S6202-3002159.
S-130-BF	130	120	. 5	HI	H17-R-6281-250	S8106-475153.
130F	130	120-240	. 36	HI	H17-R-6285-250	S8106-756851.
43159F	159	120	. 49	150	H17-R-6278-300	S8106-649187.
210F1	210	120	. 21	HI	H17-R-6278-405	S6202-3002159.
43210F	210	120	. 36	150	H17-R-6278-425	S8106-649186.
43210AF	210	120	. 21	HI	H17-R-6281-425	10-T-2010-L.

(3) *Supply switches.* Switches for connecting the coils to and disconnecting them from the power supply may be either knife switches or rotary snap switches, the rotary snap switches being preferred. All knife switches should be protected to prevent accidental contact by personnel. Satisfactory means should be provided for locking all knife switches in either the open or closed position. A double-pole single-throw supply switch should be used for the FI–QI coil (and A coil if one is installed), and a double-pole, double-throw, reversing switch with "OFF" position for the M coil and FP–QP coil. Rotary snap action switches for degaussing use should be in accordance with Military Specification MIL–S–15291 (Ships) and MIL–S–15743 (Ships).

(4) *Heading control switch and accessories.* (a) The heading control switch should be a rotary snap type reversing switch with a secure "OFF" position. The switch shall be totally enclosed so that arcing will not be visible under darkened ship conditions. The following rotary snap switches have contacts for discharge resistors (see art. 4–68 (5)):

BuShips Plan No.	*Rating*
S8106–605030	100 amperes. 250 volts d-c.
9000–S6202–C–74224 Type 20SR4S3	200 amperes. 250 volts d-c.

(b) A name plate for indicating the switch position should be provided for each heading control switch, and marked as follows:

For FI–QI coil	*For A coil*
North	East
West-East	North-South
South	West

North should correspond to positive coil polarity for the FI–QI coil, East for the A coil.

(c) A switch position indicator should be mounted on the cover or near each heading control switch for indicating the position of the switch with respect to heading. BuShips plans Nos. 10–T–2702–L and 10–T–2703–L show switch position indicator cards for FI–QI and A coils, respectively. These switch position indicator cards are a Ship Parts Supply System item under inventory control of SPCC Mechanicsburg.

(5) *Discharge resistors.* A degaussing coil is an inductive load. Opening the circuit while current is flowing causes a voltage to be induced which may, under some conditions, be high enough to damage the circuit. This danger can be avoided by reducing the coil current to a minimum before opening the circuit. The FI–QI and A coil heading control switches must, however, open the circuit while the coil current is flowing. For this reason, some heading control switches are provided with a discharge resistor and auxiliary contacts to connect the discharge resistor in parallel with the coil before the main line contacts open.

(6) *Warning name plates for switches.* A name plate reading "Reduce Coil Current to Minimum Before Opening Switch" should be attached to the switch cover or the control panel for all coil reversing and supply switches except the heading control switches for FI–QI or A coils. This warning applies to supply switches for the FI–QI or A coils.

(7) *Ammeters and shunts.* (a) See article 4–53 (5).

(b) Name plates giving the maximum permissible current in each degaussing coil should be placed near the ammeter for the coil on both the local degaussing control panel and the remote control panel (if a remote panel with ammeters is installed). The name plate should read "DO NOT EXCEED ------ AMPERES," and the value of current permitted should be that of the circuit component which has the lowest maximum current rating.

(8) *Polarity Indicator Lights.* If ammeters are not specified for the remote control panel, indicator lights should be provided to indicate the coil is energized and the polarity of the current. A suitable polarity indicator light is BuShips plan S81–920. This assembly uses a neon gas, bayonet candelabra base bulb. A series resistor should be used with this lamp as follows:

Circuits	*Resistor*
120 volt	1 watt, 40,000 ohms
240 volt	1 watt, 125,000 ohms

This type of lamp, shown on BuShips plan S81–920, will indicate polarity since the neon gas glows only around the negative plate. The assembly on which the lamps are mounted should be marked with "Degaussing Indicator" above the lamps; "Plus" to the right and "Minus" to the left of each lamp to show polarity; and a designation below each lamp to identify the coil with which the lamp is associated. One indicator light should be used for each coil and should be connected as shown on BuShips plan No. 10–T–2701–L so that the right hand plate of the lamp will glow for positive polarity of the coil and the left hand plate for negative polarity of the coil. A spare lamp should be stowed inside each box. This polarity indicator light is a Ship Parts Supply System item under inventory control of SPCC, Mechanicsburg.

(9) *Compass compensating equipment.* . Compass compensating equipment is needed to compensate magnetic compasses for the effects of degaussing coils. Information on compass compensating equipment is contained in chapter 6.

4–69. SPLIT COIL INSTALLATIONS WITH MULTICONDUCTOR COILS THROUGHOUT

The split coil degaussing installation, that is, one in which FI–QI and FP–QP coils are used instead of F and Q coils, was designed for simplicity of operation. The FP–QP coil ampere turns require no adjustment for change in course and rarely for change in magnetic latitude. A double-pole, double-throw (DPDT) rotary snap switch with OFF position is sufficient to provide three course correction for the FI–QI or A coil ampere turns. The typical multiconductor split coil degaussing installation has multiconductor M, FI–QI, FP–QP coils; a multiconductor A coil if an A coil is used; power supply from the ship's service system; and control of ampere turns by an operator who adjusts rheostats connected in series with the coils. A split coil installation using multiconductor coils throughout is shown on BuShips plan No. 10–T–2701–L.

(1) *Control equipment needed.* Each coil (M, FI–QI, FP–QP, and A) of a split coil installation with multiconductor coils throughout will have a rheostat, series resistor, supply switch, local ammeter with shunt, and indicator light or remote ammeter with shunt. In addition, the FI–QI coil (and the A coil, if installed) will require a heading control switch.

(2) *Location.* The indicator lights or remote ammeter and the heading control switch should be located either in the pilot house or in the chart house to permit ready adjustment with change in course. All other control equipment, unless otherwise directed, should be located below deck, preferably near the ship's service switchboard. The rheostats should be readily accessible. The ammeter for each rheostat should be so located that it can be read easily while the rheostat is being adjusted. Telephone or voice tube communication should exist between the remote control station and the local degaussing control station.

(3) *Connections.* The circuit connections should be made in accordance with Bureau of Ships Plan 10–T–2701–L. For each coil, the rheostat, series resistor, and ammeter shunt should be connected in series with the coil and connected to the power supply through fuses and a switch. The heading control switch for the FI–QI coil (and A coil, if installed) should be connected in the circuit on the load side of the supply switch to permit reversal of the coil current. Voltage for operation of the compass compensating coils should be obtained from a voltage drop in the series resistor.

(4) *Polarity.* The polarity of all coils should be in accordance with chapter 2. With respect to the heading control switches, the coil polarities should be as follows:

For FI–QI coil

Switch position	Polarity of FI coil	Polarity of QI coil	Range in magnetic degrees
NORTH	Positive	Negative	290° to 70°.
WEST-EAST	Not energized	Not energized	70° to 110° and 250° to 290°.
SOUTH	Negative	Positive	110° to 250°.

For A coil

Switch position	Polarity of A coil	Range in magnetic degrees
EAST	Positive	20° to 160°.
NORTH-SOUTH	Not energized	160° to 200° and 340° to 20°.
WEST	Negative	200° to 340°.

The above information is shown by BuShips plans 10–T–2702–L and 10–T–2703–L for the FI–QI and A coils respectively.

4–70. MULTICONDUCTOR SPLIT COILS WITH SINGLE CONDUCTOR M COIL

A typical installation with multiconductor split coils and a single conductor M coil supplied by a motor-generator set is shown on BuShips plan No. 10–T–2873–L. The motor-generator set is to be arranged for local control only. An indicator light (see art. 4–53 (4)) will be the only M coil equipment at the remote control station. The indicator light should be connected to the excitation supply ahead of the field rheostat to indicate whether or not the motor-generator set is in operation. The "plus" and "minus" markings on the indicator box should be omitted and the bulb socket should be mounted so that the plates of the lamp will be in a vertical line. In other respects the installation of the M coil should be in accordance with Section 4 and of the other coils in accordance with art. 4–69.

4–71. MULTICONDUCTOR INSTALLATIONS WITH INTEGRAL F AND Q COILS

Installations not of the split coil type having coils in addition to an M coil should permit adjustment of all coils from the pilot or chart house either directly or by means of remote controls. When motor-operated rheostats are used, one set of ammeters should be installed at the rheostats and one set at the remote control stations.

4-72. DEGAUSSING INSTALLATIONS FOR MINESWEEPERS

(1) *AMS vessels.* Either three course or multicourse correction will be used for coils requiring a change in current with change in heading. The reversing switches used for the three course heading control or the rheostats used for multicourse correction should be mounted in the pilot house.

(2) *AM and DMS vessels.* Multicourse correction will be used for coils requiring change in current with change in heading on AM and DMS vessels. The current magnitudes for these coils will be adjusted by rheostats connected in series with the coils and controlled from the pilot or chart house. Where manual rheostats are used for these coils, these rheostats are located in the pilot house or chart house with reversing switches for changing current direction. Where motor-driven rheostats are used for these coils, control is effected by pushbutton stations at the remote position in the pilot house or chart house and current reversal as well as adjustment of current magnitude is accomplished through the operation of these pushbuttons. Provision for reversal of current is built into these rheostats.

4-73. INSTALLATIONS WITH AUTOMATIC DEGAUSSING CONTROL

Automatic degaussing control equipment will ultimately be installed on vessels for which degaussing currents must be changed when the heading changes. The automatic degaussing control equipment receives an own ship's course signal from the gyro-synchro transmitter and, by means of a synchro system, causes the coil currents to vary in accordance with the patterns required for best degaussing protection.

Section 6—SPLITTING INTEGRAL F AND Q COILS TO FI-QI AND FP-QP COILS

4-81. GENERAL

(1) Integral F and Q coils should not be split on vessels using multiple course correction or automatic degaussing control equipment.

(2) If integral F and Q coils are installed on a vessel which does not use multiple course correction or does not have automatic degaussing control equipment, the coils should be reconnected to form FI-QI and FP-QP coils. Authorization to make this change should be requested from the Bureau of Ships.

4-82. AMPERE TURNS FOR SPLIT COILS

Data on the ampere turns needed for the FI-QI and FP-QP coils should be requested from the Bureau of Ordnance.

4-83. CABLE

The degaussing cable for the F and Q coils should be used for the FI-QI and FP-QP coils without changing its location and no new degaussing cable should be installed. It will be necessary to install some additional feeder cable or interconnecting cable but the cable already installed for this purpose should be used to the fullest extent practicable.

4-84. EQUIPMENT

A three-position, quick-break reversing switch (rotary snap with OFF position) should be provided for the FI-QI coil as a heading control switch in either the pilot house or chart house. On Naval vessels degaussing coils that can be readily reconnected for the split coil system will be controlled by either manually operated rheostats or motor-driven rheostats operated from push button control stations. The following will apply in each case.

(1) *Manual rheostat control.* (a) Where manual rheostats have been installed for controlling the currents in the integral coil system, each coil will be energized through a reversing switch. If a quick-break, three-position reversing switch is installed for the F or Q coil, it may be moved to the pilot house or chart house and used as the heading control switch for the FI-QI coil. There must be only one reversing switch in the FI-QI coil circuit, the heading control switch.

(b) The M and FP-QP coils should be energized through double-pole, double-throw (DPDT) reversing switches. Where remote ammeters have been installed, these ammeters should be left installed; in other respects the electrical circuits should be in accordance with BuShips plan No. 10-T-2701-L.

(2) *Motor-driven rheostat control.* Where motor-driven rheostats have been installed for controlling the currents in the integral coil system, each coil will be energized through a double-pole, single-throw (DPST) switch. Motor-driven rheostats have a self contained reversing switch mechanism. Arrangements should be made to eliminate the possibility of reversing current in the rheostat used for the FI-QI coil. This can be done on General Electric types by repositioning the limit switches and on the Ward Leonard types by omitting the polarity changing mechanism from the circuit. Reversal of current for the FI-QI coil should be possible at only one position, that is, by the heading control switch located in either the pilot house or chart house. The M and FP-QP coils would be energized through the DPST supply switches; current in these coils will then be reversed by the reversing mechanism in the rheostats. The remote push button controls should be relocated to be adjacent to the rheostats. Remote ammeters should be left installed; in other respects the elec-

trical circuits should be in accordance with Bureau of Ships Plan 10–T–2701–L.

4–85. MARKING

When the F and Q coils are split, all equipment should be remarked to indicate its new use and new maximum current name plates installed. All active and spare conductors in all connection and through boxes should be secured to connectors and remarked to be in accordance with chapter 2.

4–86. MODIFICATION OF SHIP'S PLANS AND REPORTS

When F and Q coils are split, the applicable degaussing plans should be modified accordingly and should indicate the plans which they supersede. New NAVORD DGP31 forms should be prepared and the modification entered on the log in the ship's degaussing folder. Copies of the DGP31 forms should be forwarded to the Bureau of Ordnance and Bureau of Ships. Copies of new plans should be forwarded to the Bureau of Ships.

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Chapter 5

INSTALLATION OF DEGAUSSING EQUIPMENT ON MERCHANT VESSELS

Section 1—GENERAL

5-1. SPECIFICATIONS

Degaussing installations on merchant vessels should conform to specifications issued by the U. S. Maritime Administration. These specifications are prepared either by the Maritime Administration or, at the request of the Maritime Administration, by the Bureau of Ships.

5-2. PLANS

The Bureau of Ships has prepared numerous plans covering methods used on naval vessels for supporting cable and sealing cable ends, mounting dimensions of equipment, electrical connections, and so on. Plans which are of particular pertinence to the degaussing installation are found in Chapter 11 of this manual.

5-3. DEGAUSSING MANUAL

This manual contains information on degaussing systems and their installation, and should be used to supplement the degaussing specifications. In case of difference between the *Degaussing Manual* and the degaussing specifications, the specifications shall govern.

Section 2—CABLE

5-11. TYPES OF CABLE

Unless otherwise specified, type MDGT cable is to be used for all degaussing coils on merchant vessels except feeder cables and cable runs installed on weather decks. Type MDGY is to be used for cable runs on weather decks, and type DDGT for feeder cables.

5-12. LOCATION OF CABLE

(1) Cable for degaussing coils forming horizontal loops (M, F, Q, I, P) should be installed within 18 inches of the skin of the vessel except where the coils pass athwartships. Any proposed diversions in excess of this figure should be approved by a Naval degaussing inspector.

(2) Cable for degaussing coils forming vertical coils (A coils, if used) should be installed as near the vertical plane through the keel as feasible.

5-13. PASSAGE THROUGH RESTRICTED SPACES

Passage of degaussing cables through refrigerators, tanks, ammunition compartments, and chain lockers should be avoided when possible. When there is no reasonable alternative, the degaussing cables should be run through the spaces, as follows:

(1) *Refrigerators*. Degaussing cables through refrigerators should be through or outboard the insulation, preferably the latter, and should either be installed in conduit or protected as necessary by a fabricated metal enclosure. The necessity for an enclosure is to be judged on the basis of the considerations in art. 5-15 (2).

(2) *Fuel oil tanks and storage compartments*. When degaussing cables are to be run through oil tanks or through compartments where drums or tanks containing gasoline or similar liquids are located, the cable should be encased in concentric pipes. The outer pipe is to be welded securely to the tank and supported as necessary within the tank. The inner pipe is to be installed concentric with the outer pipe. The inner pipe should be of sufficient diameter to accommodate the cable and stuffing tubes which shall be fitted to each end, and shall have suitable provision for drainage. The inside diameter of the outer pipe should be such as to permit a one inch axial spacing between the outside of the inner pipe and the inside of the outer pipe. Spacers should be provided to maintain this alignment. These spacers should be arranged so that any liquid which may collect within the outer pipe will flow freely along it to the lower end. Where watertight integrity is to be observed, the space between the outer and inner pipes should be blanked off at both ends by welding plates over the open ends. Provision for drainage of the inner and outer pipes should be made. The inner pipe can be extended beyond the outer pipe and drain plugs installed at the lower ends of both pipes. Where watertight integrity is not required, both ends of the outer pipe should be covered by ratproofing wire; stuffing tubes should be installed on both ends of the inner pipe. See BuShips Plan No. 9-S-3980-L.

(3) *Water tanks.* Where it is necessary to run cables through water tanks, they should be enclosed in a single pipe of suitable diameter and, if required to preserve watertight integrity, should be fitted with a stuffing tube at the higher end. The pipe should be sloped and the cable supported on spacers clear of the lower inside surface of the enclosing pipe to provide drainagee.

(4) *Powder handling and ammunition stowage compartments.* Cables passed through these areas shall be in unbroken lengths; connection or through boxes are not to be installed within these areas. Cables should be enclosed in nonwatertight, removable, sheet metal casings of sufficient strength to prevent damage to cables. Adequate drainage should be provided for casings.

(5) *Chain lockers.* Cables passed through chain lockers should be in conduit or should be protected by a removable sheet steel cover or enclosure made of ¼-inch steel plate if the cables are relatively high in the locker; otherwise, ⅜-inch steel plate or heavy steel pipe should be used.

5-14. PRECAUTIONS WHEN INSTALLING CABLE

The precautions given in arts. 4-13 (1) to 4-13 (3) should be observed when installing cable in merchant vessel degaussing systems.

5-15. CABLE SUPPORTS AND MECHANICAL PROTECTION

(1) *Cable supports.* (a) Cables should be clipped to bulkheads or frames at intervals not to exceed 16 inches. A clip approximately ⅛ inch thick and 1 inch wide is satisfactory for internal cable runs; a clip ¼ inch thick by 2 inches wide should be used for weather deck installations. On runs along the inboard edge of the frames where the frame spacing is greater than 16 inches, a backing plate or other support should be installed and the cable clipped to it so that the spacing of the cable supports does not exceed 16 inches.

(b) Where the cable pierces frames or runs through lightening holes in frames, sufficient bearing surface should be provided on the edge of the holes for proper support of the cable without chafing.

(2) *Mechanical protection.* Where cables are subject to damage from heat, fluids, or shifting cargo, they should be protected, as appropriate, by insulation or heat baffles, installed in conduit, or protected by means of a metal enclosure similar to that indicated by Bureau of Ships plan 10-T-2590-L. When conduit or pipe is used for MDGT cable, it is generally preferable to use an individual 3½-inch IPS conduit or pipe, for each cable, rather than to pass several cables through a large conduit or pipe. Provision is to be made for continuous drainage of enclosure, conduits, and pipes.

5-16. CABLES IN WEATHER DECK INSTALLATIONS

Type MDGY cable should be used for the parts of the degaussing coils on weather decks. The weather deck installation should be in accordance with art. 4-16.

5-17. STUFFING TUBES

Sizes of stuffing tubes to be used where degaussing cables pass through watertight bulkheads are given in table 3-1. Stuffing tube dimensions are shown on BuShips plan No. 9-S-5235-L.

5-18. FEEDER CABLES

(1) *Types.* Type DDGT cable should be used for feeder cables in merchant vessels. Its characteristics are given in tables 3-1 and 3-2.

(2) *Permissible voltage drop.* Customary practice specifies a maximum 5-percent voltage drop from the main distribution board to the coil connection box. In view of the fact, however, that the voltage must be reduced by as much as 40 percent on some coil designs to obtain the design value of current, it is permissible to select the feeders on the basis of current capacity, where voltage drop conditions permit.

Section 3—CONNECTION AND THROUGH BOXES

5-31. USE

(1) Unless splicing is specifically authorized, *all* connections should be made in a watertight box known as a "connection" and/or "through" box. See definitions in art. 2-21. All feeder cable or other power supply connections should be made in a connection box. Each loop of each degaussing coil should pass through a connection box. One box should be used for several loops, if possible.

(2) Through boxes can be added, where necessary, to reduce the difficulty of pulling cable but the number should be kept to a minimum.

5-32. KINDS OF BOXES

All connection and through boxes are to be watertight and are to be made of approximately ⅛ inch sheet steel. Standard degaussing connection and through boxes as shown on BuShips plans No. 9000-S8106-73142 to 73145 should be used whenever possible. Stock numbers are given in art. 4-32. If a box larger than the 80-wire size is needed, two of the standard sizes can be used. If a standard box cannot be used because of space limitations, a box should be made or procured incorporating the design features of the standard boxes insofar as possible.

5-33. LOCATION

(1) Although both connection and through boxes are to be made watertight, they should not be installed on a weather deck or be located in a compartment which may be flooded in normal opera-

tion of the vessel, such as the chain locker for example.

(2) The boxes should be located to permit ready access since it is frequently necessary to change connections during the short time allowed for ranging a vessel.

5-34. CONNECTIONS

(1) All connections within connection boxes and through boxes are to be made with solderless connectors mounted on terminal strips. The 17-conductor merchant terminal strip is mounted within the standard boxes by means of the adapter plate shown on BuShips plan No. S8106-699598. Joining conductors in connection or through boxes by solderless connectors, soldered joints, etc., without attachment to a terminal strip, is not approved.

(2) To facilitate later coil adjustments at the range, the conductors should not be served with string beyond the main trunk of the cable in connection boxes.

5-35. DRAIN HOLES

Drain holes and plugs should be provided in accordance with art. 4-36.

Section 4—POWER SUPPLY AND CONTROL EQUIPMENT

5-51. POWER SUPPLY

(1) The degaussing coils on merchant vessels are to be energized from the existing ship's service 120-volt or 240-volt d-c power supply if sufficient power is available. The power considered to be available for degaussing is the total capacity of all direct-current generators of the same voltage installed aboard ship (including stand-by generators but not including emergency generators), minus the normal sea load of the vessel. The power required for the degaussing installations should be estimated in accordance with art. 4-62 (1). If the installed generators do not have sufficient power available to take care of the degaussing load, additional generating capacity should be installed.

(2) The degaussing system should be connected to the power supply through a double-pole, single-throw (DPST) switch or a circuit breaker at the ship's service switchboard.

5-52. CONTROL EQUIPMENT REQUIRED

The current in degaussing coils on most United States merchant vessels will be controlled by a series rheostat in series with an adjustable series resistor and a switch (or switches) for opening the circuit and reversing current. Additional control equipment needed includes ammeters and indicator lights. Motor-generator sets are used in a few merchant vessel degaussing installations.

5-53. RHEOSTATS

(1) *Single circuit rheostats.* Single circuit rheostats are used to control the current in degaussing coils which have only a single circuit (see art. 2-13) or which have several parallel circuits connected together before connection to the rheostat so that as far as the rheostat is concerned there is only one circuit. The single circuit rheostats used on merchant vessels are similar to those which are used on naval vessels and which are described in art. 4-68.

(2) *Multicircuit rheostats.* (a) A single circuit rheostat would need to be of inconveniently high current-carrying capacity to control coils in which the degaussing current is large. Multicircuit rheostats are used for such coils. The coil has one to four circuits. One end of each circuit is connected directly to one side of the power supply; the other end of each circuit is connected to the other side of the power supply through the multicircuit rheostat. The multicircuit rheostat consists essentially of a 60-ampere single circuit rheostat and a switching device. Starting from the "off" position of the rheostat, continuous rotation of the control knob connects circuit A to the power supply in series with all the resistance in the rheostat; cuts out resistance in the rheostat and increases current in the degaussing coil; when all rheostat resistance is cut out, connects circuit A directly to the line and removes it from rheostat control; connects circuit B to the power supply in series with all the resistance in the rheostat; and repeats as often as necessary to connect all circuits. The number of revolutions through which the control knob must be turned to go from zero to maximum coil current is approximately 2, 3, or 4 complete revolutions for 2, 3, or 4 circuit coils respectively.

(b) Two types of four-circuit rheostats have been developed for merchant vessel installations. Each may be used for 1, 2, 3, or 4 circuit coils. Pertinent information on these rheostats, including the Bureau of Ships plan numbers, is as follows:

Rheostat	Current capacity-amperes	Circuit voltage	BuShips Plan No.
Type 1460	4 x 60	120	S6202-76028.
Type 2460	4 x 60	240	10-T-3186-L.

5-54. SERIES RESISTORS

(1) *For single-circuit rheostats.* Sufficient external series resistance should be connected in series with the rheostat to limit the current, when the rheostat is all out, to the maximum rating of the circuit. The required value of current is obtained by cutting in rheostat resistance.

(2) *For multicircuit rheostats.* (a) Four 60-ampere, 0.5-ohm series resistors are provided with

each 1460 rheostat, and three 60-ampere, 1-ohm series resistors with each 2460 rheostat. Each 1460–F resistor is rated at 60 amperes and 0.5 ohms with a center tap so that by paralleling the two 0 25-ohm sections the unit will have a rating of 120 amperes, and 0.125 ohm. Each 2,460–F resistor is composed of four 30-ampere, 1-ohm center-tapped resistors so that by paralleling the eight 0.5-ohm sections, the unit will have a rating of 240 amperes and 0.0625 ohm.

(b) The 1460–F and 2460–F paralleled resistors may be used as a resistor to provide compass compensation voltage. When used for this purpose, the resistor must be placed in one of the supply leads of the degaussing coil so that the total degaussing coil current flows through it. If the total coil current exceeds 120 amperes, two of the parallel 1460–F, 120-ampere, 0.125-ohm resistors may be paralleled together or, if available, a 43159–F or 43210–F resistor may be used. The resistor used for compass compensation should be adjusted to give a 6- to 10-volt drop at full load current; as much resistance should be used as is consistent with obtaining the maximum required coil current.

(c) The series resistor used to supply voltage drop for the compass compensating coils is in the supply lead of the degaussing coil and carries the total current in the degaussing coil, that is, the sum of the currents in all the circuits of the coil. In addition to this resistor, a separate resistor should be connected in series with each individual circuit so that this resistor carries only the current in the circuit. This resistor should have a value such that when all the resistance in the rheostat is cut out, the current in the circuit will be limited by the series resistor to the maximum current carrying capacity of the conductors or the 60-ampere rating of the rheostat, whichever is the smaller. The currents in the parallel circuits need not be equal when the coil is operating at its design value, but the maximum conductor or rheostat ratings should not be exceeded at any time.

5–55. SWITCHES

(1) *Sizes and characteristics.* Double-pole, double-throw (DPDT) and double-pole, single-throw (DPST) enclosed switches for use in merchant vessel degaussing installations are provided in the sizes shown in tables 5–1 and 5–2.

TABLE 5–1.—*Double-pole, double-throw (DPDT) enclosed switches*

Current rating (amperes)	Volts	Fused	Discharge contacts [1]	Name plate marking	Approximate outside dimensions (inches)			Standard Navy Stock Number
					H	W	D	
30	250	Yes	No		24	7½	5½	H17–TRE–T–8779.
30	250	No	No		24	7½	5½	H17–SQ–10036.
30	250	No	No	North-South	24	7½	5½	H17–SQ–10037.
30	250	No	No	East-West	24	7½	5½	H17–SQ–10038.
30	250	No	No	Positive current Negative current	24	7½	5½	H17–SQ–10039.
60	250	Yes	No		14	9½	8	H17–SQ–10040.
60	250	Yes	No		27	9	6½	H17–TRE–T–8780.
60	250	No	No	North, positive, east, west, off, south, negative.	27	9	6½	H17–SQ–10036.
100	250	No	No		31½	11	8½	H17–SQ–10041.
100	250	Yes	No		32	11	8½	H17–TRE–T–8781.
100	250	No	Yes		31½	11	8½	H17–TRE–T–10044.
200	250	Yes	No		41	16½	9½	H17–SQ–10042.
200	250	Yes	No		41	16½	9½	H17–TRE–T–8782.
400	250		No		51	21	11	H17–TRE–T–8791.
400	250	Yes	No		51	21	11	H17–TRE–T–8791.

[1] Contacts for discharge resistor.

TABLE 5–2. *Double-pole, single-throw (DPST) enclosed switches*

Current rating (amperes)	Volts	Fused	Discharge contacts [1]	Approximate outside dimensions (inches)			Standard Navy Stock No.
				H	W	D	
30	250	Yes	No	20	9	5½	H17–TRE–T–9005.
60	250	Yes	No	26½	9	6½	G17–S–52558–4227.
100	250	Yes	No	31½	11	8½	H17–CUT–4101H203.
100	250	Yes	No	31½	11	8½	G17–S–52576–1465.
200	250	Yes	No	41	16	9½	H17–CUT–4101H204.
200	250	Yes	No	41	16	9½	H17–TRE–10102.
400	250	Yes	No	51	21	11	H17–CUT–4101H205.

[1] Contacts for discharge resistor.

(2) *Warning name plates.* A name plate reading "Reduce Coil Current to Minimum Before Opening Switch" should be attached to the switch cover on the degaussing switchboards for all coil reversing and supply switches except the heading control switch for FI–QI or A coils. This warning applies to the supply switches for the FI–QI or A coils.

5–56. AMMETERS

(1) *Number.* One ammeter is to be provided for each degaussing coil to measure the coil current.

(2) *Sizes and mounting.* Condulet, zero-center ammeters are provided in 10, 20, 30, 40, 60, 80, 100, 150, 200, and 250-ampere sizes. These meters may be secured directly to a bulkhead or mounted on a short piece of conduit secured to the top of the switch enclosure. An adjustable internal series resistor is provided with each ammeter to compensate for long lead lengths between the ammeter external shunt and the meter. Generally, adjustment of this resistor will not be required if the distance from meter to shunt is less than 20 feet. See art. 4–53 (5) (c) and (d) for instructions on how to make the adjustment if it is required.

(3) *Name plates.* A name plate indicating the maximum permissible current in each degaussing coil should be located on the degaussing switchboard near the ammeter for the coil. The name plate should read "DO NOT EXCEED ______ AMPERES," and the value of current permissible should be that of the circuit component which has the lowest maximum current rating.

5–57. INDICATOR LAMPS

An indicator lamp is installed at the remote station for each coil circuit to indicate that the coil is energized and the direction of current flow. The standard commercial neon lamp contains two glow plates but, on direct current, only the plate which has *negative polarity* glows. This characteristic makes the lamp a simple polarity indicating device since the tube can be connected across the degaussing circuit so that with positive current flow to the coil, the right-hand plate will glow and when the polarity of the coil is reversed, the left-hand plate will glow. The polarity of a degaussing coil is defined in chapter 2. The tube itself will contain no internal resistor but will be used in series with a 40,000-ohm, 1 watt, external resistor for 120-volt circuits and a 125,000-ohm, 1 watt, external resistor for 240-volt circuits. An additional advantage of this tube is that it can withstand considerable over-voltage without damage. This characteristic is of particular value in the FI–QI circuit where high voltages will be encountered when the reversing switch is operated under current carrying conditions. The indicator lamp is to be connected to the switch terminals on the coil side of the DPDT reversing switches of the coils. Connected in this manner, the lamp will indicate polarity and the fact that the coil is energized. One indicator lamp should be provided for each coil at the remote station, i. e., chart house or pilot house. The indicator lamps should be visible to the operator of the FI–QI heading control switch. Details of the indicator lamp are listed on BuShips plan S81–920.

5–58. LOCATION OF CONTROL EQUIPMENT

(1) *Engine room.* The rheostats, series resistors, ammeters, and reversing and disconnect switches (with the exception of the FI–QI heading control switch) should all be grouped together at some convenient station in the engine room. It is imperative that the station selected be easily accessible for adjustment of the controls at any time. In addition, it should be near some station that is constantly attended and from which an operator is readily available to make current adjustment upon order from the bridge. The rheostats and series resistors should be completely enclosed by an expanded metal screen unless they are already enclosed. A drip shield should be placed above the rheostats to prevent any liquids from dripping on the rheostat elements. The switches may be mounted on supporting angle framework or on a metal panel. An important consideration in the placement of this equipment is that the ammeter should be located close enough to the associated coil rheostat so that an operator adjusting the rheostat can read the ammeter.

(2) *Chart or pilot house.* The indicator lights and any associated FI–QI heading control switch should be grouped together in the Chart or Pilot House. On most vessels, it will be preferable to locate this equipment in the Pilot House. The heading control switch will be a DPDT enclosed switch and should be located at some point where it can be conveniently operated as the ship changes heading. The indicator lights should be located so that they are not visible outside the vessel.

5–59. COMMUNICATION

Voice tube or telephone communication should either exist or be provided between the remote control station (indicator lights) and the control equipment in the engine room. It is not necessary that this communication extend directly to the control equipment but should be close enough so that the operator who receives the order can either operate the control equipment himself or designate someone else to make the requested adjustment.

5–60. COMPASS COMPENSATION

Compass compensating coil equipment is required to compensate the magnetic compasses on a vessel for the effects of the degaussing coils. On new construction vessels compass coils and associated equipment are to be installed currently with the degaussing system during construction of the vessel. Types of compass compensating equipment used, installation information, and information relative to compensation of compass coils are contained in chapter 6.

Section 5—SPLITTING INTEGRAL F AND Q COILS TO FI–QI AND FP–QP COILS

5–71. GENERAL

If integral F and Q coils are installed on a vessel which does not have multiple course correction or automatic degaussing control equipment, the coils should be reconnected to form FI–QI and FP–QP coils. Authorization to make this change should be requested from the Bureau of Ships.

5–72. AMPERE TURN REQUIREMENTS

When F and Q coils are to be split, data on the ampere turns required for the FI–QI and FP–QP coils should be requested from the Bureau of Ordnance.

5–73. MARKING

When F and Q coils are split, the applicable degaussing plans should be modified accordingly. These plans should indicate the plans which they supersede. New DGP31 forms should be prepared and the modification entered on the log in the degaussing folder. Copies of the DGP31 forms should be forwarded to the Bureau of Ordnance and Bureau of Ships. Copies of the new plans should be forwarded to the Bureau of Ships.

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Chapter 6

COMPASS COMPENSATING COILS AND COMPASS COMPENSATION

Section 1—FUNCTIONS AND TYPES OF COMPASS COMPENSATING COILS

6–1. REASONS FOR COMPASS COMPENSATION

Degaussing coils produce a large magnetic field to counteract the magnetic field of a ship and thus degauss the ship. If it were not compensated, the magnetic field produced by the degaussing coils would cause the magnetic compass to be in error. To prevent this, compass compensating coils are fitted to neutralize the magnetic field produced by the degaussing coils at the compass so that the compass will be unaffected by the degaussing coils. The effect of compass compensating coils is to "undegauss" the ship in the immediate vicinity of the magnetic compass or compasses.

6–2. COMPONENTS TO BE COMPENSATED

(1) *Resolution into components.* Present practice in compass compensation for degaussing is to compensate individually for each of the three components into which the magnetic field of a degaussing coil can be resolved. The resolution into components can be made in an infinite number of ways of which only the two shown in Tables 6–1 and 6-2 are used in compass compensation for degaussing.

TABLE 6–1.—*Resolution of a magnetic field into 3 components with cardinal horizontal components*

Component	Direction
H	Vertical
B	Horizontal, fore-and-aft
C	Horizontal, athwartships.

TABLE 6–2.—*Resolution of a magnetic field into 3 components with intercardinal horizontal components*

Component	Direction
H	Vertical
NE	Horizontal, 45° from center line of ship.
NW	Horizontal, 45° from center line of ship.

(2) *Directions.* The directions given in the preceding tables are the component directions when the ship is on an even keel. When the ship rolls or pitches, the directions of the components move with the ship. Since the magnetic field produced by a coil fastened to the ship also moves with the ship, the magnitudes of the H, B, and C or H, NE, and NW components of magnetic field produced by degaussing coils and compass compensating coils are not changed by rolling or pitching of the ship.

(3) *Cardinal and intercardinal components.* The B and C components are known as cardinal components because they line up with the cardinal points (N, S, E, W) of the compass when the ship is on a N or S heading. The NE and NW components are known as intercardinal components because they line up with the intercardinal points (NE, SE, SW, NW) when the ship is on a N or S heading.

6–3. COILS FOR COMPENSATING THE H COMPONENT

Almost all degaussing coils produce an H component of magnetic field at the compass. This causes no compass deviation when the ship is on an even keel and the H component is vertical. When, however, the ship heels, the H component is no longer vertical and will cause a compass deviation. To prevent this, the compass is fitted with a compass compensating coil called the heeling coil. The heeling coil is placed around the binnacle in a plane perpendicular to the H direction, hence, in a plane which is horizontal when the ship is on an even keel. The axis of the heeling coil passes through the center of the compass needle. The heeling coil produces at the compass needle a magnetic field which is in the H direction and as nearly as possible equal and opposite to the H component of magnetic field produced at the compass by the degaussing coil. The result is neutralization of the H component of magnetic field produced at the compass by a degaussing coil, and, hence, elimination of the compass deviation which would otherwise be produced by the H component of the degaussing coil field. A heeling coil is used in all types of compass compensating coils. Note that the H component, as the term is used in compass compensation, is the component which must be compensated to prevent compass deviations when the ship heels—it is *not* a horizontal component.

6-4. COILS FOR COMPENSATING HORIZONTAL COMPONENTS

In addition to the vertical component, a degaussing coil also produces a horizontal component of magnetic field at the compass. The horizontal component is the one which is resolved into the B and C or the NE and NW components. The horizontal component produces compass deviation irrespective of whether the ship is on an even keel or not. This can be seen from fig. 6-1. Assume that the ship is on an even keel, that E represents the horizontal component of the earth's field at the compass, and that D represents the horizontal component of the magnetic field produced by a degaussing coil. The resultant of E and D is R. The compass will point in the direction of R instead of in the direction of E, the correct direction, and will be in error by the angle θ. Since E is fixed in direction while the direction of D changes with the ship's heading, the compass deviation θ will change with heading unless D is compensated. Compensation is effected by fitting a coil or coils to produce at the compass a magnetic field equal to —D which cancels D and leaves the compass unaffected by the degaussing coil. A single vertical coil in a plane perpendicular to D was used at first and was known as "Mark I". This type of installation has the disadvantage of requiring large coils which must be movably mounted so that they can be aligned to match the direction of the magnetic field they are to compensate. Since a separate compass coil had to be used for compensation of each degaussing coil, the result was a cumbersome installation. This system is no longer used. In all present types of compass compensating coils, two coils (or two sets of coils) are used to produce magnetic fields which are mutually perpendicular and which are oriented to compensate either the cardinal or the intercardinal components of the magnetic field produced by the degaussing coils.

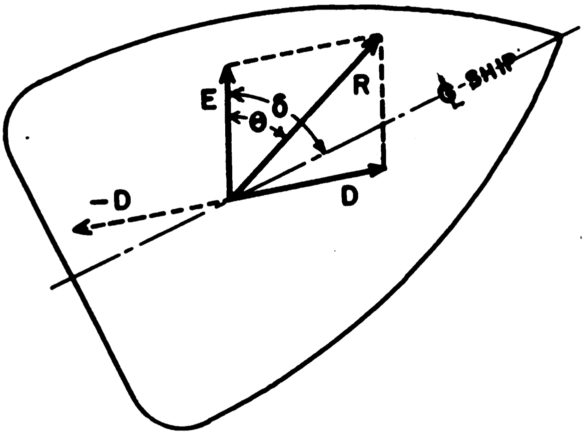


Figure 6-1. Effect of degaussing coil magnetic field on magnetic compass.

6-5. COILS FOR COMPENSATING B AND C COMPONENTS

The coils compensating the B and C or the cardinal components are mounted as shown in fig. 6-2.

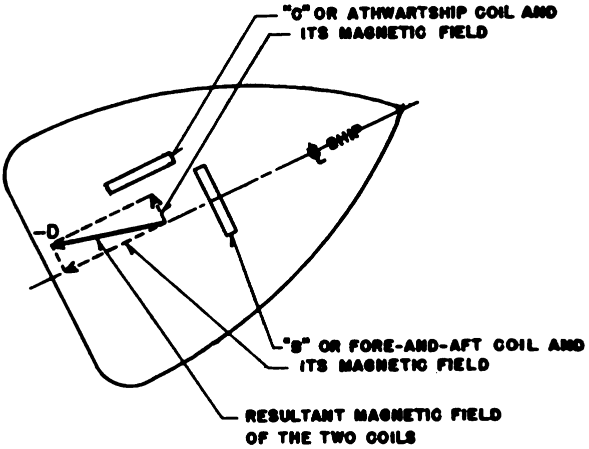

"C" OR ATHWARTSHIP COIL AND ITS MAGNETIC FIELD
℄ SHIP
–D
"B" OR FORE-AND-AFT COIL AND ITS MAGNETIC FIELD
RESULTANT MAGNETIC FIELD OF THE TWO COILS

Figure 6-2. Compensation of cardinal components of degaussing coil magnetic field.

The B coil produces a magnetic field equal and opposite to the B component of the magnetic field produced by a degaussing coil; the C coil produces a magnetic field equal and opposite to the C component of the magnetic field produced by a degaussing coil. The magnitudes of the magnetic fields produced by degaussing coils and compensating coils are proportional to current so long as magnetic saturation effects are not involved, hence, for compensation of a degaussing coil magnetic field, the current through the compass compensating coil must be proportional to the current through the degaussing coil. This is arranged by taking power for the compass compensating coil from a fixed resistor connected in series with the degaussing coil. The voltage drop across the resistor and the current through the compass compensating coil are automatically proportional to the degaussing coil current.

6-6. COILS FOR COMPENSATING THE NE AND NW COMPONENTS

Coils for compensating the NE and NW (intercardinal) components are mounted as shown in fig. 6-3.

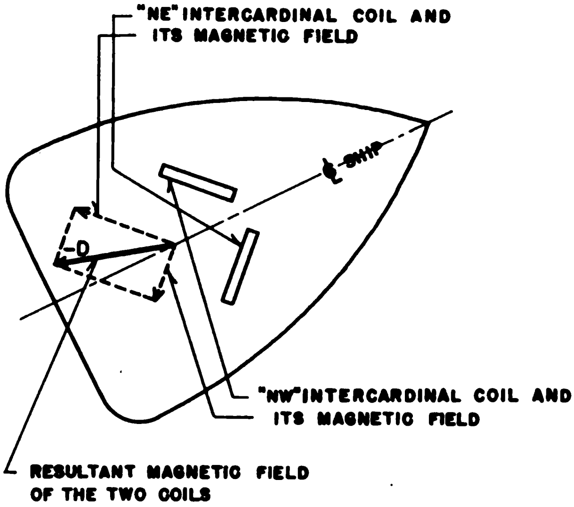

"NE" INTERCARDINAL COIL AND ITS MAGNETIC FIELD
SHIP
-D
"NW" INTERCARDINAL COIL AND ITS MAGNETIC FIELD
RESULTANT MAGNETIC FIELD OF THE TWO COILS

Figure 6–3. Compensation of intercardinal components of degaussing coil magnetic field.

6–7. TYPES OF COMPASS COMPENSATING COILS

Various types of compass compensating coils which are or have been in use and the horizontal components which they compensate are given in table 6–3. All types compensate for the H or vertical component. More detailed information on each type of coil is given in Section 2.

Table 6–3

Type of compass compensating coil	Horizontal components of magnetic field which are compensated
Type "A"	Cardinal.
Type "B"	Cardinal.
Type "B-Mod."	Cardinal.
Type "C"	Cardinal.
Type "C-Special"	Cardinal.
Type "G"	Intercardinal.
Type "K"	Intercardinal.
Type "K-1"	Intercardinal.
Type "K-2"	Intercardinal.
Type "Filled K"	Intercardinal.
Type "R-1"	Cardinal or Intercardinal.
Type "R-2"	Cardinal or Intercardinal.
Type "T"	Cardinal or Intercardinal.
Type "TE"	Cardinal.

Section 2—INSTALLATION OF COMPASS COMPENSATING COILS

Part 1—GENERAL

6–11. VESSELS ON WHICH COMPASS COILS SHOULD BE INSTALLED

(1) *New construction vessels.* Compass compensating coils should be installed on all new construction vessels with degaussing systems unless compass compensation is shown to be unnecessary by the tests given in arts. 6–12 (2) and 6–12 (3).

(2) *Conversions.* Compass compensating coils should be installed on degaussed vessels undergoing conversion unless compass compensation is shown to be unnecessary by the tests given in arts. 6–12 (2) and 6–12 (3), or unless the previously installed compass compensating coils are satisfactory. The compass compensating coils installed before the conversion period should be retained unless they are obsolete and require replacement (see article 6–13 (1)). When major changes in the degaussing system are made, changes in ampere-turns or cable runs, for example, the compass coil control equipment may require modification in order to provide compensation for increased or decreased degaussing coil effects (see articles 6–81 (1) and 6–12 (2)).

(3) *Operating vessels.* If it is found by inspection or otherwise that either the standard or the steering compass of a degaussed ship is not compensated, the compass should be checked in accordance with arts. 6–12 (2) and 6–12 (3) to see if compensation is required. If it is, compass compensating coils should be installed at the first opportunity.

6–12. WHICH COMPASSES SHOULD BE COMPENSATED

(1) *Standard and steering compasses.* Both the standard and the steering compasses on both naval and merchant vessels should be compensated except as indicated in arts. 6–12 (2) and 6–12 (3).

(2) *Test for need of horizontal compensation.* Compass compensation for horizontal components of magnetic field is not needed if tests made on the compass show that the maximum deviation caused by degaussing is less than 3°. The check on the necessity of compensation for horizontal components should be made on both cardinal and intercardinal headings and with all combinations of degaussing coil currents which the vessel will use. It is important to make sure that the maximum deviation caused by the degaussing coils is found. When making this test, the ship is not placed on cardinal and intercardinal headings but the compass is deflected to the desired direction by a deflecting magnet (art. 6–124).

(3) *Test for need of vertical compensation.* Heeling compensation, or compensation for the vertical component of magnetic field, may be needed even if the degaussing coils produce no compass deviations when the ship is on an even keel. To check on the necessity for heeling compensation, a calibrated dip needle should be placed in the binnacle in place of the compass. The calibrated dip needle is used to measure the vertical component of magnetic field produced at the compass by the degaussing coils. A heeling coil should be installed if the maximum vertical component of magnetic field exceeds 20 milligauss for any combination of degaussing coil currents. Compensation should be provided for each coil causing a vertical component at the compass of 10 milligauss or more.

(4) *If test is not made.* Compass compensating coils should be installed if it is not possible to make tests in accordance with arts. 6–12 (2) and 6–12 (3) to determine whether compass compensation is needed or not.

6–13. TYPE OF COIL TO INSTALL

The type of compass coil to be installed in any particular installation will be specified in the compass coil specification letter or the degaussing coil specification letter for the installation. The type chosen is selected so as to make best use of the numerous types of compass compensating coils that have been developed. Some of the types are now obsolete and should be removed and replaced by new types; other types are to be left in place where they are now installed, if in good condition, but are not to be used for new installations or for replacing other coils; and still others are the modern standard types which are to be used for new installations and replacement of older types.

(1) *Types to be removed.* The following types of compass compensating coils are to be removed from *all* installations in which they are found, regardless of the condition of the coils, and replaced with modern standard types at the first opportunity:

Mark I.
Mark II.
Mark III.
Type "A" Flinders bar coils.
Type "A" sphere coils.
Type "B" Flinders bar coils.
All *locally* manufactured compass coils.

None of the above types is to be used for new installations or replacements. The type of coil for replacement is to be chosen in accordance with art. 6–13 (3).

(2) *Types to be left installed but not used for new installations or replacements.* The following types are to be left in place in installations where they now occur provided the coils are in good condition and there is no indication of approaching failure:

Type "B" (except Flinders bar coil—see art. 6–13 (1)).
Type "B-Mod."
Type "C."
Type "C-Special."
Type "G."
Type "K."

None of the above types is to be used for new installations or for replacement of coils which have been removed because they are defective or show signs of approaching failure. The type of coil for the replacement is to be chosen in accordance with art. 6–13 (3).

(3) *Standard types.* The present standard types of compass compensating coils and their uses are given in table 6–4.

TABLE 6–4.—*Standard types of compass compensating coils*

Type	Use
Type "A"	The type "A" heeling coil is used only on binnacles which prefabricated coils (types listed below) do not fit. Type "A" Flinders bar coils and sphere coils are obsolete, are to be removed from all installations in which they are found, and are not to be installed.
Type "G-Mod"	Fits USN standard No. 2 shelf type binnacle, and odd shape and size merchant binnacles. Is usually the most suitable type of coil for boat or shelf compasses. Can be adapted to fit almost any compass installation. Consists of type "G" horizontal component coils and a type "A" heeling coil.
Type "K-1", Type "K-2", Type "Filled K".	These three types are interchangeable except where quadrantal cylinders instead of quadrantal spheres are used for normal compass adjustment. In this special case, "K-2" coils will not fit. Fit USN standard Mark VII binnacle, USN standard No. 1 shelf type binnacle, all types of binnacles on merchant ships built for U. S. Maritime Commission in World War II. These are the latest types of general purpose compass compensating coils (Type "K-2" not yet available as of March 1952 but expected by August 1952). First choice for all applications where the coils fit. Also to be used for replacement of type "K" coils which are removed because they are defective or show signs of impending failure (see art. 6–13 (2)). Selection of one of these three types is made on the following basis: (a) Type "K-1" suitable for use in locations reasonably well protected from weather. (b) Type "Filled K" to be used for locations exposed to severe weather and sea conditions until type "K-2" becomes available, after which type "Filled K" is to be used like type "K-1". (c) Type "K-2", when it becomes available is to be used for locations exposed to severe weather and sea conditions, as on DD's and DE's, for example.
Type "R-1"	The type "R-1" coil is used for compensation of the USN No. 5 boat compass, the USN No. 3 compass, and the modified magnesyn compass. The assembly for use in small mine sweeping boats is furnished as a complete unit and consists of an "R-1" coil, a No. 5 boat compass, and a mounting stand. When used to compensate the No. 3 compass the coil is supported by brackets or collars to accommodate special compass mounting, as on DDE's for example.
Type "R-2"	Is a modification of Type "R-1", and has the same applications. Is not available as of March 1952, but is expected to be by June 1952.
Type "T"	For magnesyn, flux-gate, slave-gyro, and USN No. 6 vehicle type compasses, also USN No. 5 boat compass and USN No. 3 shelf type boat compass if type "T" coil has adequate strength of field and number of circuits.
Type "TE"	The "TE" coil is used to compensate a new light-weight compass. The coil fits within the pedestal assembly. Use of this coil with other compasses with special mounting arrangements is anticipated. Not available as of March 1952 but is expected to be by June, 1953.

6–14. TYPE OF COIL FOR SECOND COMPASS INSTALLATION

If a ship has one compass compensated with intercardinal coils, the second compass should also be fitted with intercardinal coils whenever practicable. Similarly, when cardinal coils are specified by the Bureau for one compass, the second compass should also be fitted with cardinal coils.

6–15. GROUNDING OF CASES

The case of each compass compensating coil should be *securely grounded.*

6-16. PROCUREMENT OF MATERIAL

Information as to the source of supply for compass compensating coils, control boxes, and cables will be included in the compass coil specification letter or the degaussing coil specification letter issued by the Bureau of Ships for each installation. Incidental materials are supplied by the installing yard. If the installing yard is not a U. S. Navy activity and is unable to obtain nonmagnetic terminal tubes, the terminal tubes needed should be obtained for the yard by the local Industrial Degaussing Group from U. S. Naval Shipyard, Portsmouth, N. H., which maintains an adequate stock of aluminum and brass terminal tubes for compass coil installations.

6-17. GENERAL INSTALLATION INSTRUCTIONS

The installation should be made as directed by the local Industrial Degaussing Group which will furnish advice on the number of degaussing coils that require compensation and on the type of compass coil to be installed (if this is not specified by the Bureau of Ships). This Group will also furnish detailed installation instructions, and will make the dockside compensation (see art. 6-112 (2)) after the installation is completed.

6-18. SCOPE OF THE FOLLOWING INSTRUCTIONS

The following installation instructions are confined to modern standard types of compass compensating coils (art. 6-13 (3)). All other types are either to be removed regardless of condition (art. 6-13 (1)), or are to be removed and replaced by modern types when in need of repair (art. 6-13 (2)).

Part 2—TYPE "A" HEELING COIL

6-21. GENERAL

Type "A" compass compensating coils were made by winding multiconductor cable around the binnacle to compensate the H component, around the Flinders bar to compensate the **B** component, and around the spheres to compensate the C component. Type "A" Flinders bar and sphere coils are to be removed from all old installations in which they may be found and replaced with modern types of coil. Type "A" heeling coils are still used in conjunction with type "G" intercardinal coils on odd shaped non-standard diameter, or foreign binnacles which prefabricated heeling coils do not fit. Such an installation is known as type "G-Mod.". The type "A" heeling coil is inferior to prefabricated heeling coils in waterproof integrity, simplicity of installation and maintenance, appearance, and resistance to abrasion. It should not be used when a prefabricated coil can be fitted.

6-22. INSTALLATION OF COIL

The type "A" heeling coil is made by wrapping the required number of windings about the binnacle, approximately at the level of the compass card. Each winding, one for each degaussing coil to be compensated, usually has five turns of MDGB-12 (1) cable wound snugly in one layer and secured at each end with clips, leaving a sufficient length of cable at each end to make connections in the terminal box. In addition to the end clips on each winding, other clips shown in fig. 6-4 are used to hold the entire coil firmly in position.

6-23. TERMINAL BOX

The type "A" terminal box is used to connect the conductor ends of each cable in series to make one continuous circuit from the twelve conductors in the cable. One terminal box can accommodate up to three windings, and permits connection to a supply cable.

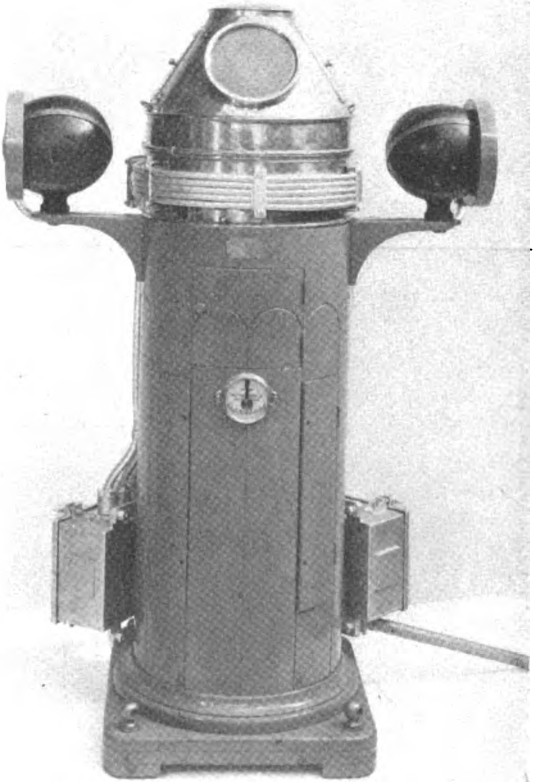


Figure 6-4. Type "A" heeling coil. The sphere coils shown in this photograph are obsolete.

6-24. INSTALLATION PRECAUTIONS

Special attention should be given to the cable entrance glands and the cover gasket on the terminal box to make sure that the installation is sealed against the entrance of moisture.

Part 3—TYPE "G-MOD" COILS

6-31. GENERAL

Type "G-MOD" compass compensating coils consist of type "G" intercardinal coils and a type "A" heeling coil. Type "G-MOD" is especially suitable for use on Navy Standard No. 2 and No. 3 binnacles and non-standard merchant ship binnacles which the heeling coils of type "G", "K-1", "K-2", and "Filled K" assemblies of heeling coil and intercardinal coils do not fit. These assemblies are interchangeable, but the Type "G" assembly is no longer used for new installation or replacements being superseded by Types "K-1", "K-2", or "Filled K." Hence, for binnacles which the heeling coil of the Type "G" or the K types of assembly fits, one of the K types of assembly should be used. For binnacles which the heeling coil does not fit, type "G" intercardinal coils are used with a type "A" heeling coil. This combination is known as type "G-Mod" and is shown in fig. 6-5.

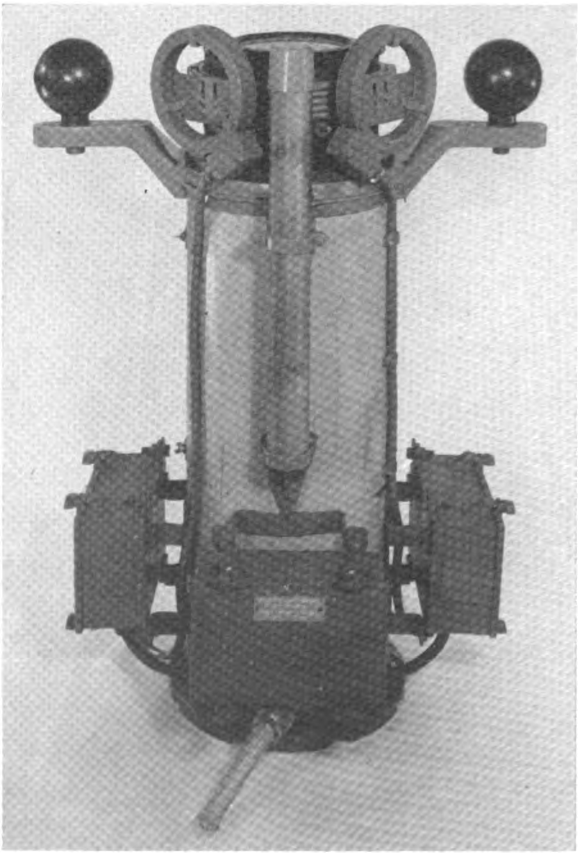


Figure 6-5. Type "G-MOD" compass compensating coil assembly, consisting of type "G" intercardinal coils and type "A" heeling coil, mounted on a plywood stand.

6-32. DESCRIPTION

Type "G" coils (see fig. 6-6) are manufactured commercially. They consist of one heeling coil, which is no longer used for new installations or replacements but is left in use in older installations when in good condition (see art. 6-13 (2)), and two intercardinal coils. The coils are vacuum impregnated with insulating material and completely enclosed in a watertight brass casing. Each coil is provided with a terminal box for making electrical connections to the coil circuits. The coils have the following characteristics:

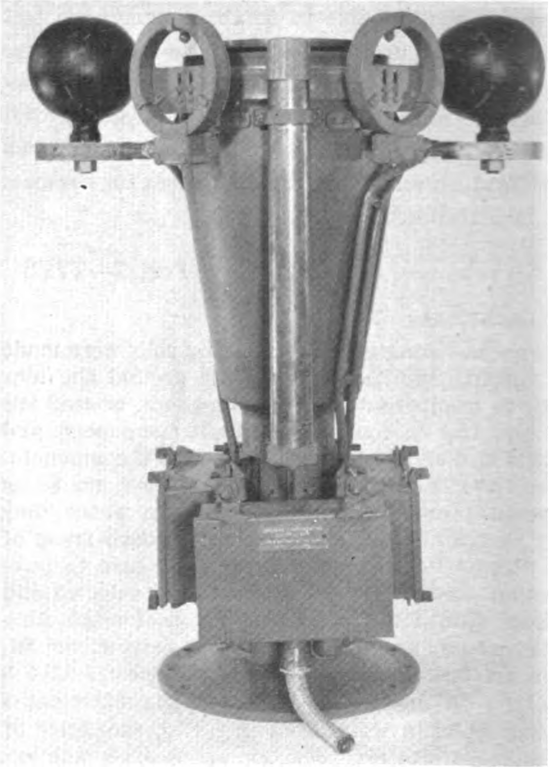


Figure 6-6. Type "G" coil assembly mounted on Nav Mark VII binnacle. The type "G" heeling coil is n longer used for new installations or replacements b is left in use in older installations when in good condition.

	Heeling coil	Intercardinal c
No. of windings per coil	4	3.
No. of turns per winding	60	66.
Wire	No. 18 single glass enamel.	No. 20 single gl enamel.
Resistance per winding (85° F. ambient).	1.6 ohms ±7 percent	1.2 ohms. ±7 percent.
I. D. of coil casing	$14\frac{1}{8}$ inches	$5\frac{29}{32}$ inches.
O. D. of coil casing	$15\frac{5}{8}$ inches	$7\frac{5}{8}$ inches.
Height of coil casing	$1\frac{3}{4}$ inches	$1\frac{1}{8}$ inches.
Maximum permissible voltage (80° F. ambient temperature).	2.2	1.7.

6-33. HEELING COIL

The type "A" heeling coil which forms a part of the type "G-Mod" coil installation is described in arts. 6-21 to 6-24.

6-34. INTERCARDINAL COILS

(1) The intercardinal coils are attached to brackets for mounting on the binnacle. The brackets are mounted so that the axes of the coils lie in the plane of the compass card 90° from each other and 45° from the forward lubber line. The brackets are equipped with horizontal slots and the bracket plates with vertical slots to permit mechanical and magnetic alignment. The brackets are deep enough to provide clearance for the heeling coil.

(2) The intercardinal coils must be mounted rigidly. Some merchant type binnacles with thin brass shells must be reinforced by wooden blocks shaped to form a sector fitting the inside of the binnacle, or by brass bars shaped to fit the binnacle and attached by bolts or brazing. In addition to reinforcing the shell, it is also advisable to attach a rod or strap from the top "Z" clamp of the intercardinal coil to the clamp for the binnacle hood, or directly to the binnacle itself, above the heeling coil.

(3) Fig. 6–7 illustrates the mounting of four intercardinal coils when more than two are needed.

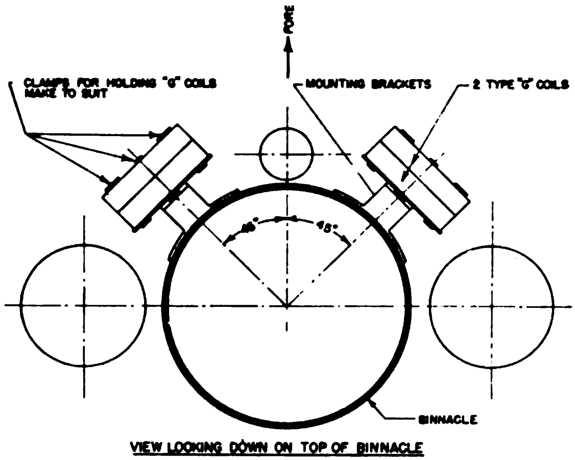

FORE
CLAMPS FOR HOLDING "G" COILS MAKE TO SUIT
MOUNTING BRACKETS
2 TYPE "G" COILS
45°
BINNACLE
VIEW LOOKING DOWN ON TOP OF BINNACLE

Figure 6–7. Method of mounting two sets of type "G" coils to provide additional circuits.

Since each coil has only three windings, this need will arise if more than three degaussing coils require compensation, for example, M, I, P, and A coils, or if only three degaussing coils need compensation but compass compensating coil windings must be used in series to produce sufficient magnetic field strength for compensation. The method of mounting four coils shown in fig 6–7 is preferable to mounting one coil at each of the four intercardinal points because it creates less obstruction to viewing the compass.

6-35. STRENGTH OF COIL

Fig. 6–8 shows the relation between the coil current and the compass deviation produced by a type "G" intercardinal coil.

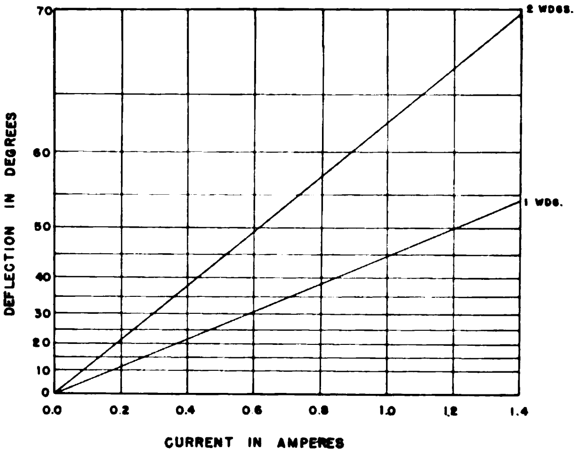


Figure 6–8. Current-deflection curves for type "G" intercardinal coils. The upper curve is for the deflection produced by any two windings connected in series; the lower curve is for the deflection produced by a single winding. Both curves are for a directive force (horizontal component of earth's magnetic field) equal to 180 milligauss, and for coil and compass needle so oriented that when there is no current in the coil the needle is perpendicular to the direction of the magnetic field which the coil produces when the current is turned on. If the directive force is greatly different from 180 milligauss, the deflection should not be read from the curves but should be computed from:

$$\tan \theta = Ai/F$$

where i=current in amperes
F=directive force in milligauss
A=350 for two windings in series
=178 for one winding.

6-36. INSTALLATION PRECAUTIONS

(1) Before installing a Type "G" compass compensating coil assembly, measure the resistance of each winding and the insulation resistance from each winding to the case. When the insulation resistance of a winding is measured, all other windings should be electrically connected to the case. The resistances of the windings should either be within, or not far beyond limits given in the table in art. 6–32, and the insulation resistance of each winding should be in excess of 2 megohms. If not, another coil assembly with satisfactory resistances should be used.

(2) Make sure that the intercardinal coils are rigidly fastened. Avoid sharp points or corners or projecting parts as much as possible.

Part 4—TYPES "K-1", "K-2", AND "FILLED-K" COILS

6-41. GENERAL

These three types are interchangeable. Type "K–2" (see fig. 6–9) differs from type "K–1" (see fig. 6–10) in case design and mounting arrangement. Type "Filled K" (see fig. 6–11) differs from type "K–1" in being filled with an insulating compound to prevent low insulation resistance even if cracks develop in the soldered seams of the brass

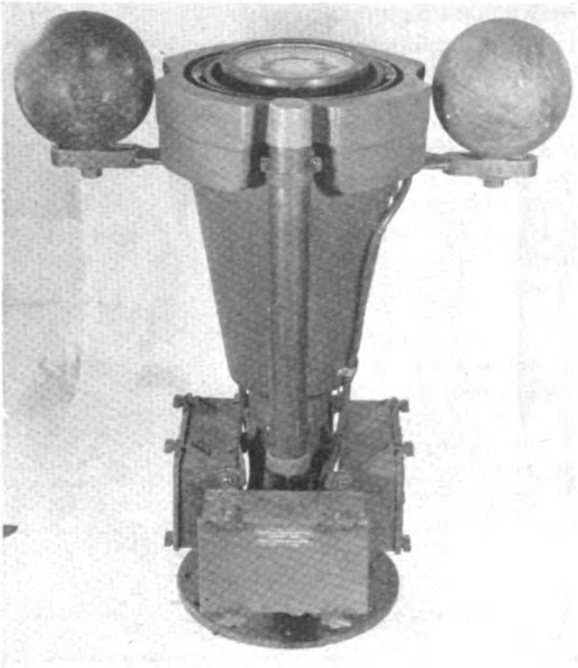


Figure 6–9. Type "K–2" coil assembly.

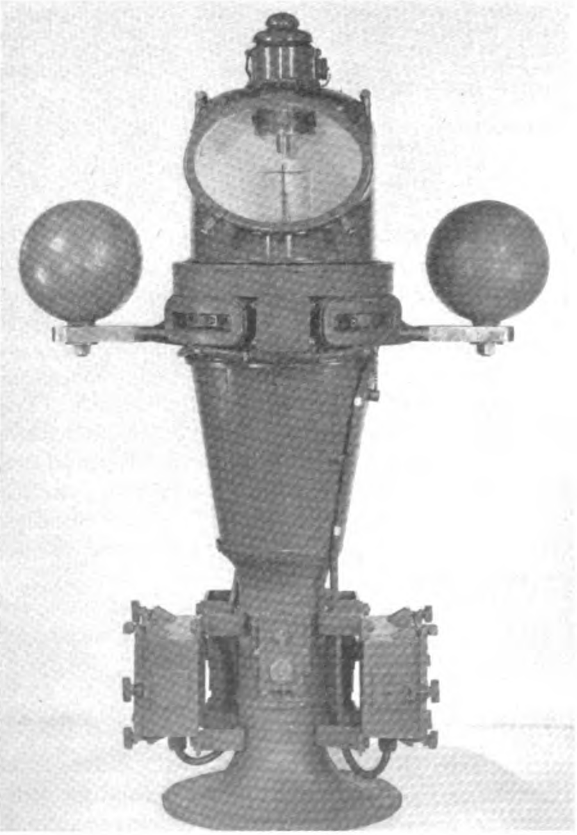


Figure 6–10. Type "K–1" coil assembly.

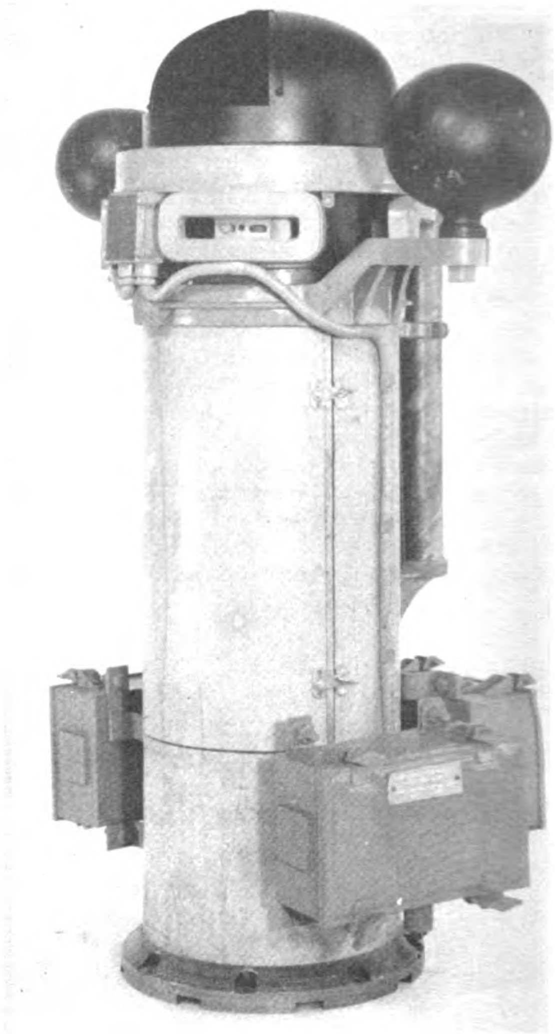


Figure 6–11. Type "Filled K" coil assembly.

enclosure. Type "K–1" coils manufactured in the future will also be filled with insulating compound. See art. 6–13 (3) for information on the use of and choice between the three types.

6–42. DESCRIPTION

(1) *General characteristics.* All three types consist of five vacuum impregnated coils of four windings each enclosed in a hermetically sealed drawn brass enclosure, a connection box where coil connections are made, and two 12-conductor cable leads 10 feet long entering the connection box through stuffing glands. One of the five coils is the heeling coil, the other four are intercardinal coils 90° apart with horizontal axes which intersect the heeling coil axis 2¾ inches below the center of the heeling coil. A single coil below the compass needles would produce an appreciable vertical component of magnetic field at the needles, hence

orresponding windings of two diametrically oppo- ite intercardinal coils are connected in series so hat the horizontal components of magnetic field dd while the vertical components cancel.

(2) *Coil characteristics.* The four windings in he heeling coil are for compensation of the H omponent; the four windings in one pair of two iametrically opposite intercardinal coils are for ompensation of the NE component; and the four indings in the other pair of intercardinal coils re for compensation of the NW component. The oils have the following characteristics:

	Heeling coil	Intercardinal coils
o. of windings per coil	4	4.
o. of turns—winding No. 1	60	150.
o. of turns—windings No. 2, 3, 4.	60	75.
ire	No. 18 single glass enamel.	No. 20 single glass enamel.
esistance of winding No. 1 in ohms (80° F. ambient).	1.6±7 percent	5.1±7 percent.
esistance of windings No. 2, 3, and 4 in ohms (80° F. ambient).	1.6±7 percent	2.3±7 percent.
D. of assembly	14⅞ inches	
. D. of heeling coil (shim flinders bar to this point).	16³⁄₃₂ inches	
ax. height of assembly (not including cable clamp).	5²³⁄₃₂ inches	
ax. current per winding, amps.	2.0 [1]	1.4.
Max. permissible volts on winding No. 1 (80° F. ambient temperature).	3.2 [1]	7.0.
Max. permissible volts on windings No. 2, 3, and 4 (80° F. ambient temperature).	3.2 [1]	3.2.

[1] Although heeling coil windings are capable of carrying 2 amperes ontinuously, parallel connection of control resistors is required for a rrent in excess of 1.4 amperes.

(3) *Over-all dimensions.* Over-all dimensions of the type "K" and "K–1" coils are shown on Bureau of Ships drawing No. S8106–435094 (see fig. 6–12) and No. S8106–719451 (see fig. 6–13), respectively.

6–43. STRENGTH OF FIELD

(1) The relation between compass deflection and coil current in one pair of series connected type "K–1," "K–2," or "Filled–K" intercardinal coils is shown in fig. 6–14. The strength of the magnetic field produced by the heeling coil is shown on fig. 6–15.

(2) Under unusual conditions, it may not be possible to produce sufficient field strength without exceeding current ratings of the coils or resistors. In this case, two windings are connected in series and are controlled by one resistor network.

6–44. AUXILIARY EQUIPMENT

Auxiliary equipment supplied in the shipping case with a type "K–1," "K–2," or "Filled K" assembly

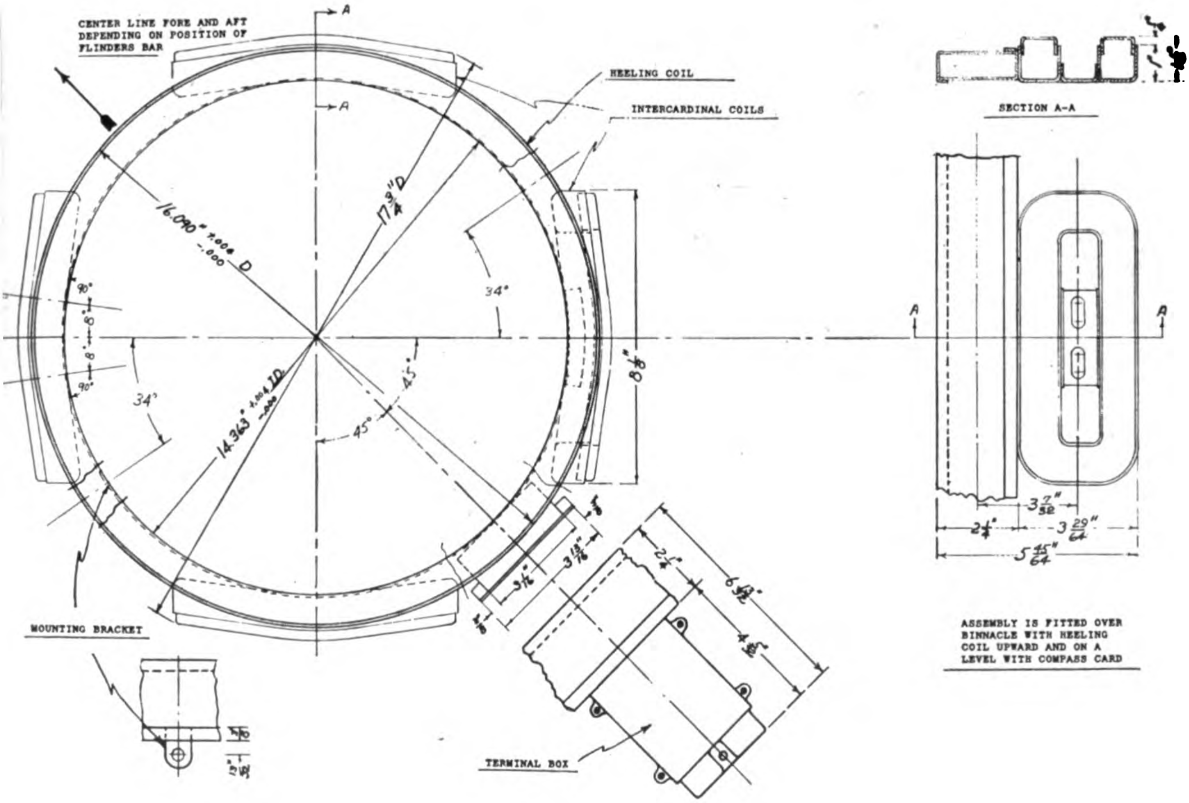


Figure 6–12. Dimensions of type "K" compass compensating coil assembly.

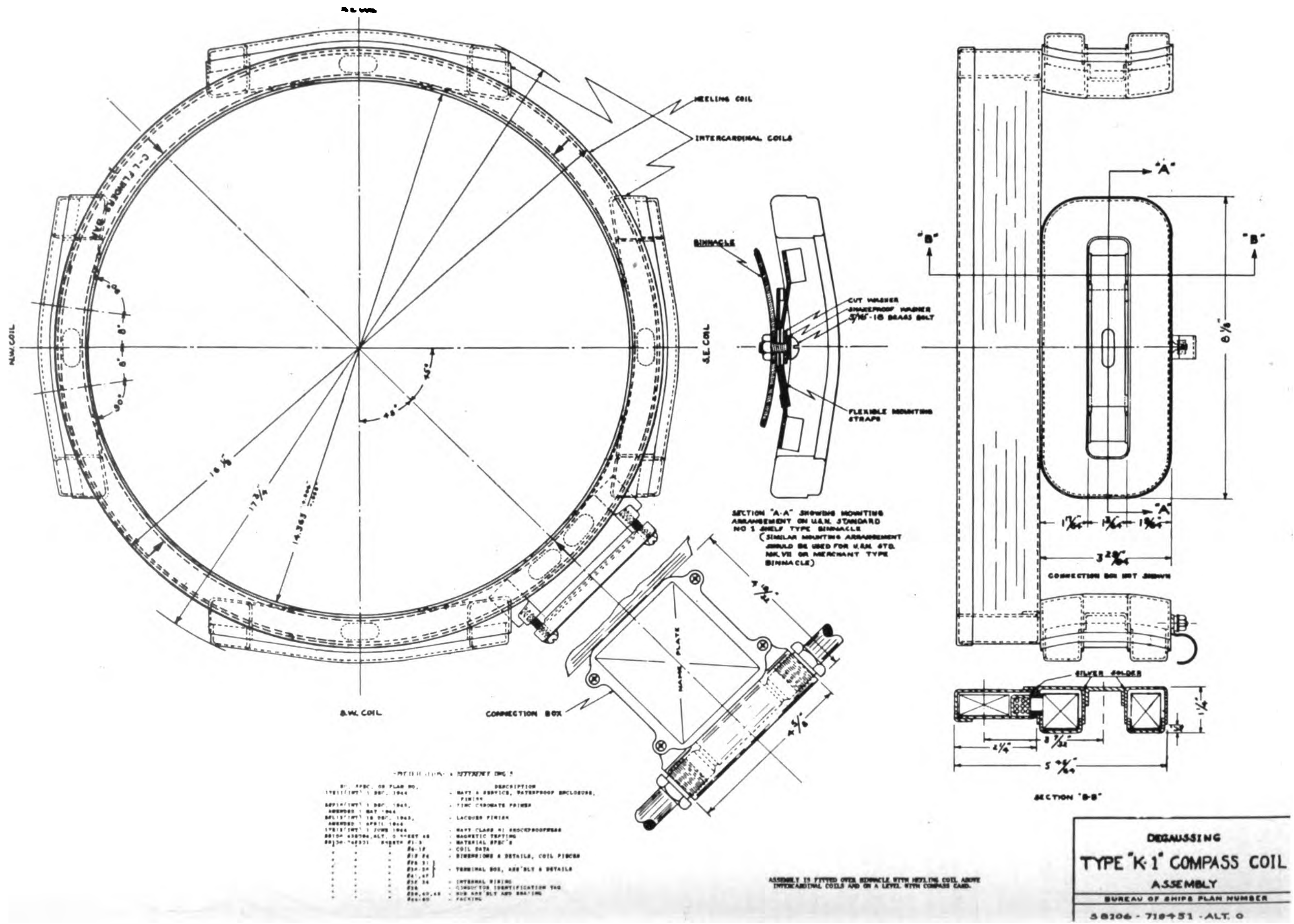


Figure 6-13—Dimensions of type "K-1" compass compensating coil assembly.

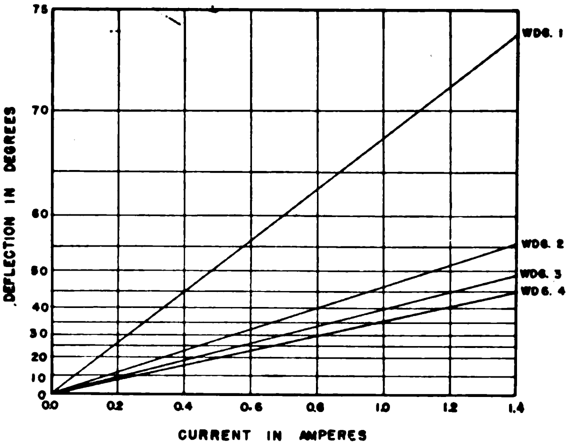


Figure 6–14. Current-deflection curves for type "K-1", "K-2", and "Filled K" intercardinal coils. The deflections are those produced by one pair of intercardinal coils with corresponding windings in the two coils connected in series. All curves are for a directive force (horizontal component of earth's magnetic field) equal to 180 milligauss, and for coils and compass needle so oriented that when there is no current in the coils the needle is perpendicular to the direction of the magnetic field which the coils produce when the current is turned on. If the directive force is greatly different from 180 milligauss, the deflections should not be read from the curves but should be computed from:

$$\tan \theta = AI/F$$

where I = current in amperes
F = directive force in milligauss
A = 445 for winding No. 1
= 190 for winding No. 2
= 150 for winding No. 3
= 130 for winding No. 4

includes mounting bolts with spacers, cable clamps, and a drilling template for the coils.

6–45. INSTALLATION INSTRUCTIONS

The assembly is fitted over the binnacle as a unit so that the intercardinal coils hang below the heeling coil, the axis of the heeling coil coincides with the axis of the binnacle, and the heeling coil is approximately at the level of the compass card. See figs. 6–9, 6–10, and 6–11. Detailed installation instructions are included in the packing case with ach unit.

–46. INSTALLATION PRECAUTIONS

(1) *Alignment.* Magnetic A error may have ne- essitated rotation of the binnacle away from the hip's fore-and-aft line. If this is the case, the rrows on the coil assembly should not be aligned vith the binnacle lubber lines but should be aligned arallel to the ship's center line.

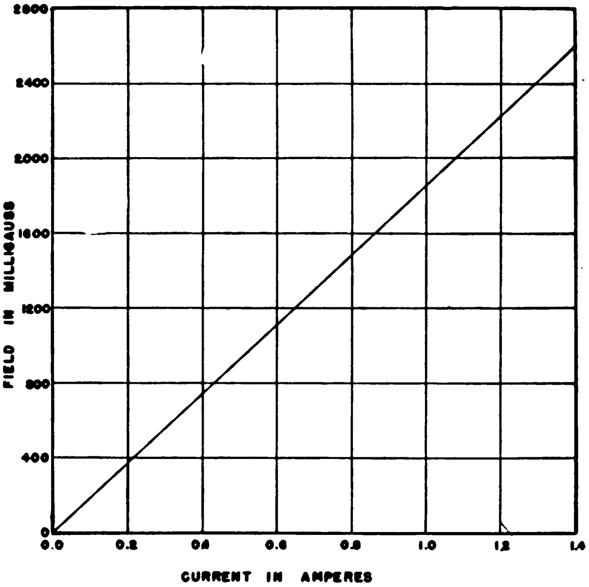


Figure 6–15. Magnetic field produced by one winding in type "K-1", "K-2", and "Filled K" heeling coils.

(2) *Mounting.* The K type coils ("K-1," "K-2," "Filled K") require a great deal of care in mounting to make sure that no stresses are applied to the soldered seams. These coils *must be shimmed* to within 1/16 inch of the binnacle OD.

(3) *Resistance measurement before installation.* Before installing Type "K-1", "K-2", or "Filled K" coils, measure the resistance of each winding and the insulation resistance from each winding to the case. When the insulation resistance of a winding is measured, all other windings should be electrically connected to the case. The resistances of the windings should either be within or not far beyond the limits given in the table in art. 6–42 (2), and the insulation resistance of each winding should be at least 2 megohms. If not, another coil assembly with satisfactory resistances should be used.

(4) *Serial number.* The serial number on most type "K-1", "K-2", or "Filled K" coils is stamped on the inside of the terminal box cover. *The cover should not be removed* just to obtain this number to fill in the CC-1 form unless trouble is encountered on that particular coil.

(5) *Modifications.* When it is necessary to remove *hood clips, shutter levers,* or other auxiliary compass equipment to adapt the coil to the binnacle, the navigator should be informed of the change.

Part 5—TYPE "R-1" COIL

–51. DESCRIPTION

Type "R-1" is used for compensating USN No. 3 ompass. The type "R-1" coil assembly is a single oughnut shaped unit (fig. 6–16) consisting of five oils, vacuum impregnated with insulating varnish or resin and arranged in a rigid subassembly; a watertight brass container, hermetically sealed; and two eight-foot, twelve-conductor, type MDGB-12 (1½) cables entering the assembly through L shaped terminal tubes. The completed assembly is

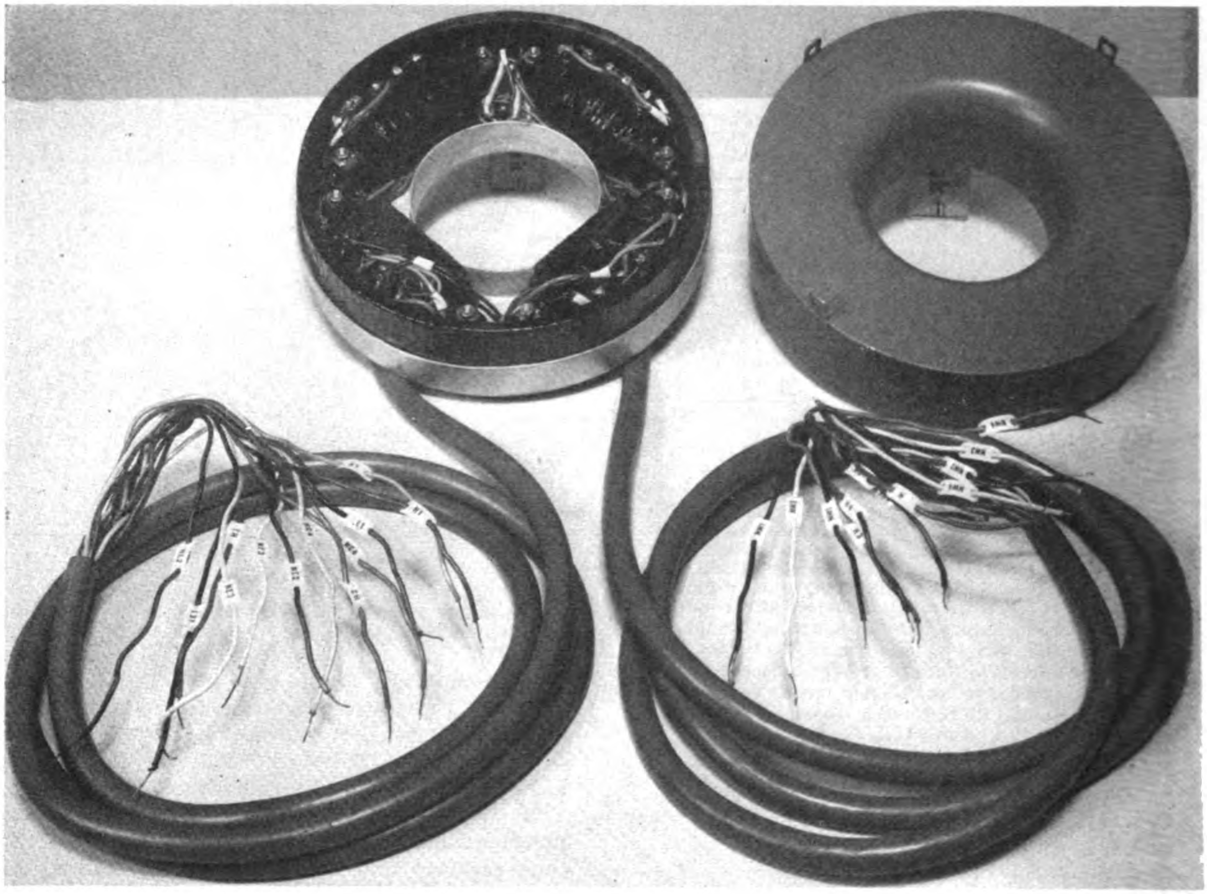


Figure 6–16. Type "R–1" compass compensating coil assembly.

filled with insulating compound. One of the coils is for compensating the H component; two diametrically opposite intercardinal coils are for compensating the NE component; and the other two diametrically opposite intercardinal coils are for compensating the NW component. The unit is placed several inches below the compass to be compensated, and the return field of the intercardinal coils is used for compensation.

6–52. COIL CHARACTERISTICS AND DIMENSIONS

(1) *Coil characteristics*. Corresponding windings in two diametrically opposite intercardinal coils are connected in series, making two pairs of intercardinal coils, one pair for the NE component and one pair for the NW component (see fig. 6–17). Coil characteristics are as follows:

	Heeling coil	Inter-cardinal coils
Number of windings per coil	4	4
Number of turns:		
Winding No. 1	153	365
Winding No. 2	102	360
Winding No. 3	51	342
Winding No. 4	51	342
Wire size AWG, single paper covered Formvar or similar	No. 20	No. 21
Resistance, ohms (80° F. ambient temperature)		
Winding No. 1	4.1	4.3
Winding No. 2	2.7	3.4
Winding No. 3	1.4	2.7
Winding No. 4	1.4	2.1
Maximum current, amperes (80° F. ambient temperature)	1.0	1.0
Maximum outside diameter, inches	$9\frac{17}{32}$	$2\frac{1}{4}$

(2) *Dimensions of unit.* The dimensions of the watertight enclosure are:

Outside diameter of enclosure (max.) inches, $9\frac{13}{16}$.

Inside diameter of enclosure (min.) inches, $4\frac{5}{16}$.

6–53. COIL STRENGTH

The compass deflection produced by one pair of series-connected intercardinal coils is shown in fig. 6–18. The strength of the magnetic field produced by the heeling coil is shown in fig. 6–19.

6–54. INSTALLATION

(1) When used to compensate the USN No. 3 compass, the R–1 coil assembly is mounted with the

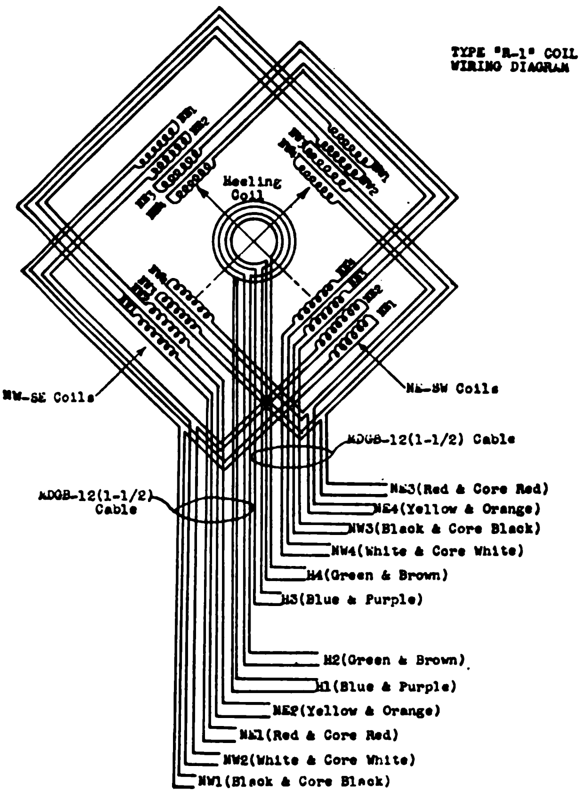


Figure 6–17. Wiring diagram for type "R–1" compass compensating coil assembly.

heeling coil in a plane parallel to the plane of the compass needles. The center of the assembly should be approximately 5¼ inches below the plane of the compass needles. It should be supported by collars or brackets to accommodate special compass mounting, as on DDE's for example. The four clips brazed to the top of the coil enclosure should be used only to prevent motion of the coil assembly in azimuth. The coil assembly is oriented in azimuth so that the arrow on the top of the coil enclosure (which indicates "Flinders bar, Intercardinal Mounting") is aligned along a line parallel to the centerline of the vessel. The axis of the coil should be colinear with that of the compass.

(2) For compensating the USN No. 5 boat compass an "R–1" coil assembly complete with compass and mounting stand is furnished. The No. 5 compass binnacle is oriented in azimuth so that its "fore" and "aft" markings describe a line parallel to the centerline of the vessel. The "R–1" coil assembly is oriented in azimuth so that the arrow on the enclosure (which indicates "Flinders bar, Intercardinal Mounting") is aligned in a plane formed by the line described by the "fore" and "aft" markings of the compass binnacle, and its vertical axis.

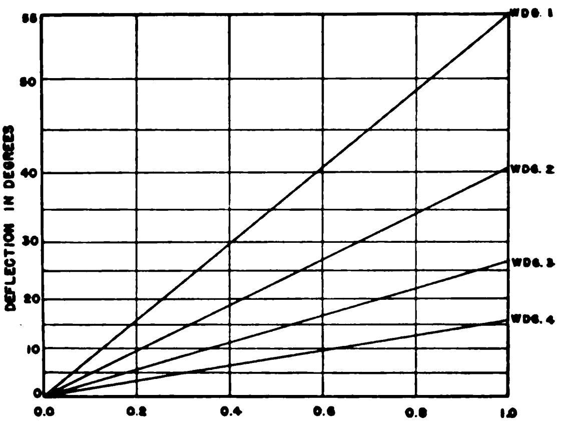


Figure 6–18. Current-deflection curves for type "R–1" intercardinal coils. The deflections are those produced by one pair of intercardinal coils with corresponding windings in the two coils connected in series. All curves are for a directive force (horizontal component of earth's magnetic field) equal to 180 milligauss, and for coils and compass needle so oriented that when there is no current in the coils the needle is perpendicular to the direction of the magnetic field which the coils produce when the current is turned on. If the directive force is greatly different from 180 milligauss, the deflections should not be read from the curves but should be computed from:

$$\tan \theta = \frac{Ai}{F}$$

where i = current in amperes

F = directive forces in milligauss

A = 255 for winding No. 1

= 155 for winding No. 2

= 90 for winding No. 3

= 52 for winding No. 4

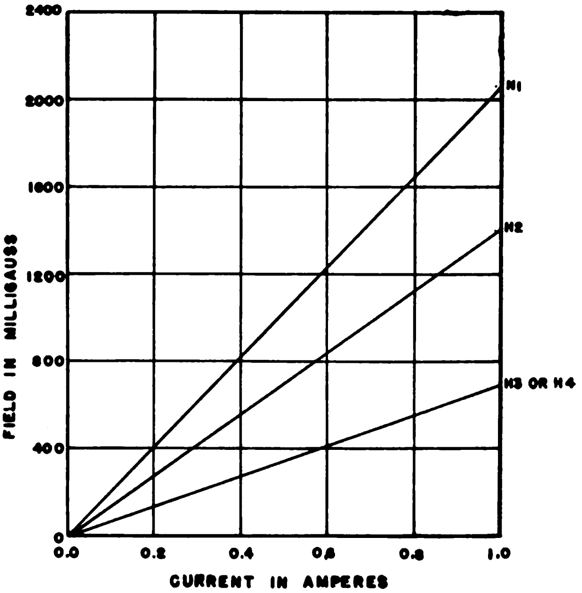


Figure 6–19. Magnetic field produced by type "R–1" heeling coil windings.

6–55. PRECAUTIONS

(1) Before installing Type "R–1" coils, measure the resistance of each winding and the insulation resistance from each winding to the case. When the insulation resistance of a winding is measured, all other windings should be electrically connected to the case. The resistances of the windings should agree with the values given in the table of art. 6–52 to within about ten per cent, and the insulation resistance of each winding should be at least megohms. If not, another coil assembly with sat factory resistances should be used.

(2) The coil cap should not be removed by the i stalling or repair activity when a coil is found to b defective. The defective coil should be replac with a satisfactory coil and returned to the rep department for drying out, minor repair, or replac ment.

Part 6—TYPE "T" COIL

6–61. USE

The type "T" coil was designed for use primarily with the transmitters in magnesyn compasses on coiled ships. Magnesyn compasses are remote indicating compasses with compass needles in a magnesyn transmitter which sends indications out to one or more receivers. Type "T" compass compensating coils may also be used with special compasses such as the "vehicle" or "boat" types provided adequate mounting facilities are available or can be constructed.

6–62. DESCRIPTION

(1) *General.* The type "T" compass coil assembly, see figs. 6–20 to 6–22, is a single unit which can be mounted for either cardinal or intercardinal compensation. It has one heeling coil (H coil), one NE or B coil, and one NW or C coil. The heeling coil compensates for vertical magnetic field at the compass. When mounted intercardinally, the NE and NW coils compensate for the NE and NW components, respectively. When mounted cardinally, the NE and NW coils (B and C coils), compensate for the B (fore-and-aft) and the C (athwartships) components, respectively.

(2) *Construction.* The T-coil unit has nine separate compensating windings, three H windings, three NE (or B) windings, and three NW (or C) windings mounted within a cylindrical aluminum housing. The three sets of windings are mutually perpendicular and are wound on a cylindrical block, the H winding coaxial with the block producing a vertical field, and the NE (or B) and NW (or C) windings perpendicular to H winding producing horizontal fields. The H coil is approximately 4 inches in diameter; the NE and NW coils are approximately 4 inches square. Each end of each winding is connected at an internal terminal strip to one conductor of an MHFF–19 cable. The nineteenth conductor (blue with red tracer) of the cable is used to anchor the cable to the coil block and is not connected in any circuit. A 25-foot length of cable is provided with each assembly. The assembly is designed for mounting below the compass to be compensated. The mounting flange is provided with twelve holes for various mounting arrangements and an arrow pointing "Fore". The NE or B and the NW or C coils each produce at the

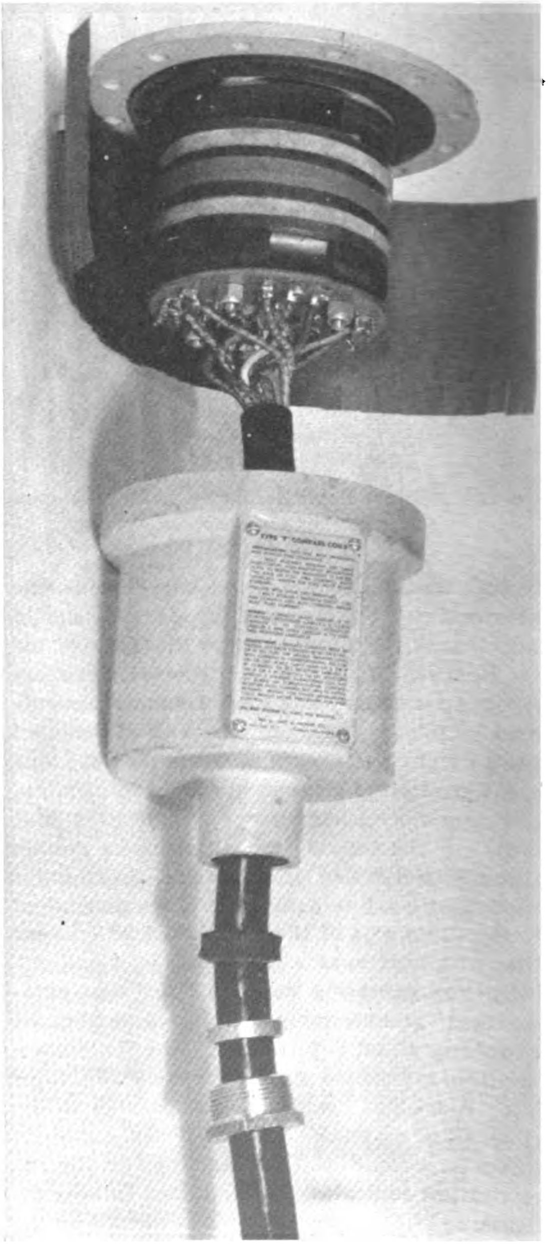


Figure 6–20. Type "T" compass coil assembly with ternal parts removed from case.

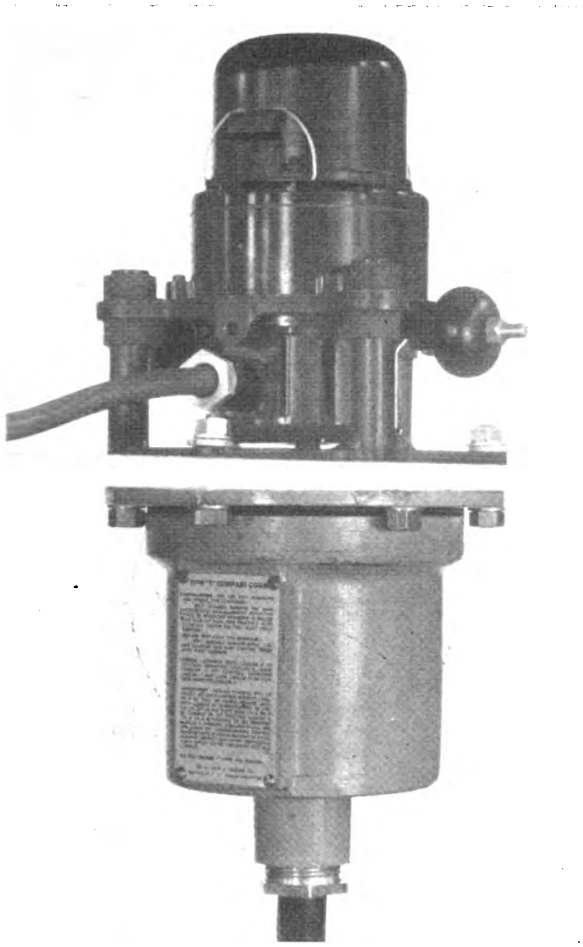


Figure 6–21. Type "T" compass coil assembly mounted below a magnesyn transmitter.

compass a magnetic field which is opposite in direction to the field inside the coil.

6–63. COIL CHARACTERISTICS

The approximate characteristics of type "T" coils are as follows:

	H coil	NE or B coil	NW or C coil
Number of windings per coil	3	3	3
Number of turns per winding	152	100	[1] 100
Approximate resistance per winding, ohms (80° F. ambient temperature)	4.1	2.9	[1] 2.9
Maximum current per winding, amperes (80° F. ambient temperature)	1.0	1.0	1.0
Maximum permissible voltage per winding (80° F. ambient temperature)	4.1	2.9	[1] 2.9

[1] Type "T" coils with serial number 40 and less (serial number is stamped on name plate) were intended for cardinal mounting and have C or NW coils with the following characteristics:

Number turns per winding: 76.

Approximate resistance of each winding (80° F. ambient): 2.2 ohms.

Maximum permissible voltage per winding (80° F. ambient): 2.2 volts.

Maximum compensation per winding (H=180 mg): 48°.

6–64. COIL STRENGTH

(1) The coil strength for type "T" coils is shown in figs. 6–23 and 6–24.

(2) Under unusual conditions, it may not be possible to produce sufficient field strength without exceeding the current ratings of the coils or resistors. In this case, two windings are connected in series and are controlled by one resistor network.

6–65. INSTALLATION

When used on a magnesyn transmitter, the type "T" coil and the transmitter mounting brackets are bolted coaxially to a nonmagnetic plate with the transmitter above the plate and the type "T" coil below the plate as illustrated in fig. 6–21. The coil is oriented cardinally or intercardinally to correspond with the type of compass coils installed on the ship's standard and steering magnetic compasses.

(1) *Intercardinal.* For intercardinal mounting, the arrow of the type "T" coil flange should be aligned 45° from the center line, pointing to the starboard bow. When so aligned, the mounting plate can be drilled and tapped for nine short ⅜ inch diameter tap screws. The transmitter is fastened to the top of the plate with three tap screws, and the coil assembly is fastened to the bottom of the plate with six tap screws. It is better, however, to drill three holes through the type "T" coil flange and the mounting plate at the positions which are punchmarked on the type "T" coil flange. Three bolts through these holes can be used for mounting both the transmitter and the compass coil unit, and will ensure accurate alignment. Both the transmitter flange and the mounting plate have holes which match those drilled through the flange of the type "T" unit at the punchmarks.

(2) *Cardinal.* For cardinal mounting, the arrow on the type "T" coil flange should point forward. In this position, holes in the transmitter mounting flange and the mounting plate coincide with three holes on the type "T" coil flange permitting the use of through bolts at these positions.

6–66. INSTALLATION PRECAUTIONS

(1) Type "T" compass coils require considerable attention to alignment of the vertical axis with the compass pivot because the heeling coil has a steep magnetic gradient around the coil axis.

(2) Before installing Type "T" coils, measure the resistance of each winding and the insulation resistance from each winding to the case. When the insulation resistance of a winding is measured, all other windings should be connected to the case. The insulation resistance and winding resistances should be within the limits given below, otherwise another coil with satisfactory resistances should be used.

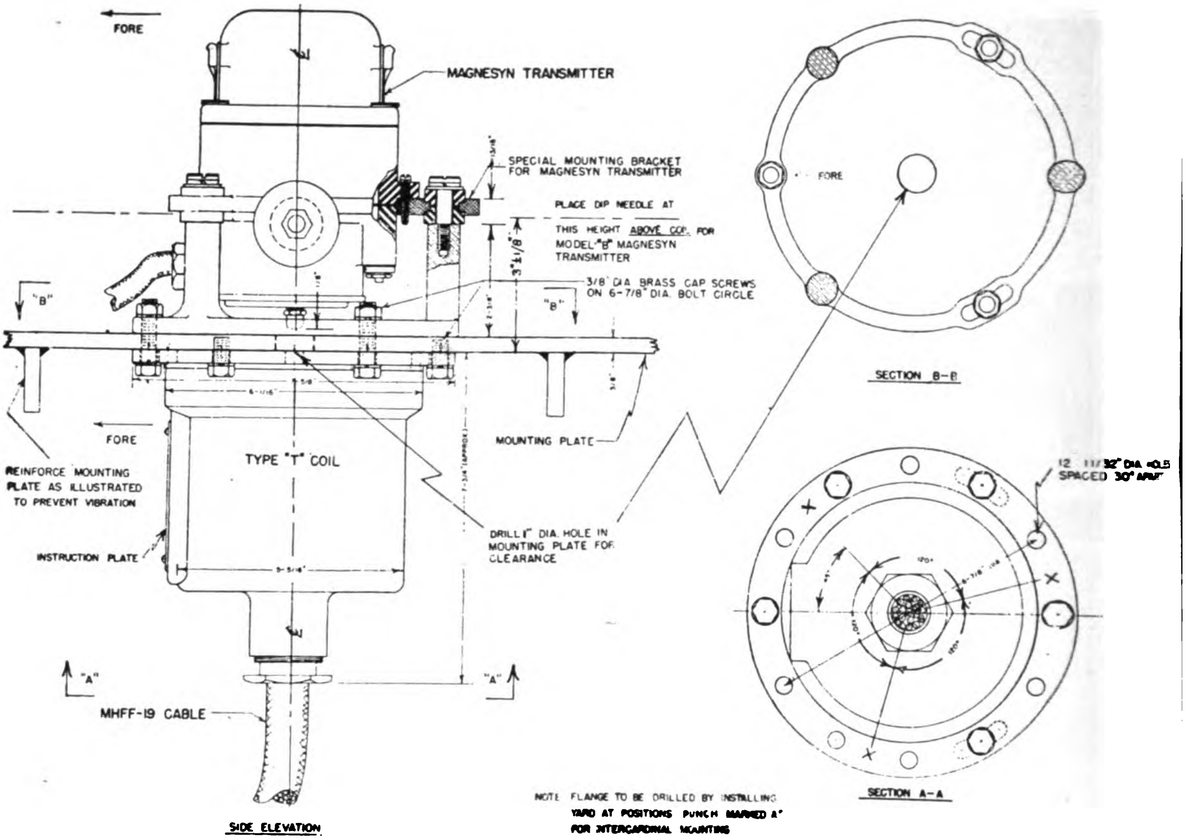

FORE
MAGNESYN TRANSMITTER
SPECIAL MOUNTING BRACKET FOR MAGNESYN TRANSMITTER
PLACE DIP NEEDLE AT THIS HEIGHT ABOVE COP. FOR MODEL "B" MAGNESYN TRANSMITTER
3"±1/8"
3/8" DIA BRASS CAP SCREWS ON 6-7/8" DIA. BOLT CIRCLE
"B"
"B"
FORE
REINFORCE MOUNTING PLATE AS ILLUSTRATED TO PREVENT VIBRATION
TYPE "T" COIL
MOUNTING PLATE
DRILL 1" DIA. HOLE IN MOUNTING PLATE FOR CLEARANCE
INSTRUCTION PLATE
"A"
"A"
MHFF-19 CABLE
SIDE ELEVATION
FORE
SECTION B-B
12 11/32" DIA HOLE SPACED 30° APART
120°
120°
120°
SECTION A-A
NOTE FLANGE TO BE DRILLED BY INSTALLING YARD AT POSITIONS PUNCH MARKED A" FOR INTERCARDINAL MOUNTING

Figure 6–22. Dimensions of type "T" compass compensating coils and arrangement for mounting with magne transmitter.

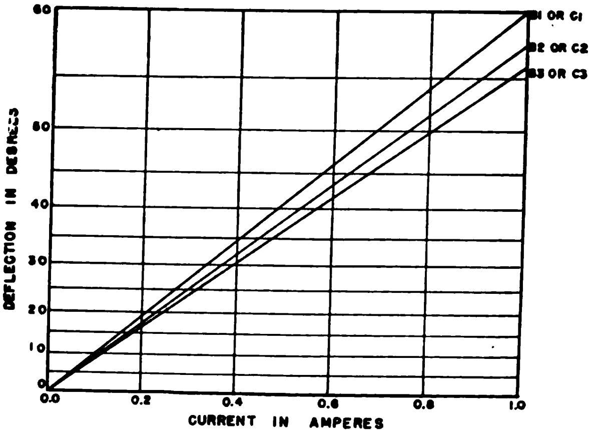


Figure 6–23. Current-deflection curves for type "T" coils for compensating cardinal or intercardinal components. All curves are for a directive force (horizontal component of earth's magnetic field) equal to 180 milligauss and coil and compass needle so oriented that when there is no current in the coil the compass needle is perpendicular to the direction of the magnetic field which the coil produces when the current is turned on. If the directive force is greatly different from 180 milligauss, the deflection should not be read from the curves but should be computed from:

$$\tan \theta = AI/F$$

where I = current in amperes
F = directive force in milligauss
A = 315 for winding No. 1
= 285 for winding No. 2
= 270 for winding No. 3

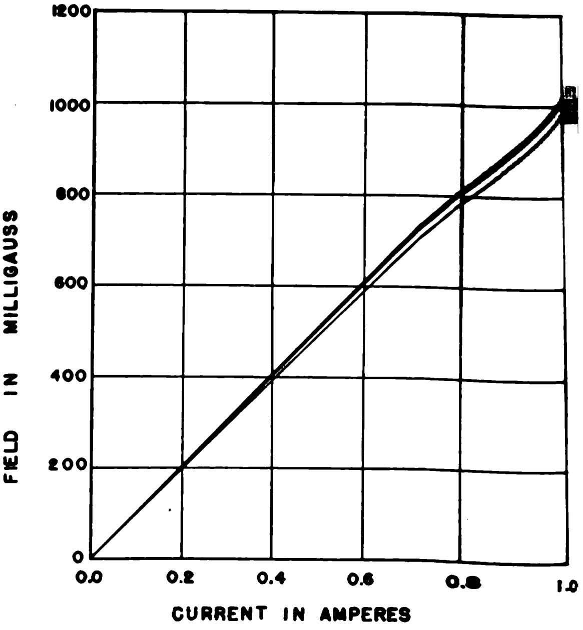


Figure 6–24 Magnetic field produced by type "T" heeli coil windings.

	Minimum	Maximum
Insulation resistance between windings or between any winding and case	2 megohms.	
Resistance of heeling winding (80° F. ambient temperature)	3.4 ohms	4.8 ohms.
Resistance of NE winding (80° F. ambient temperature) all serial numbers	2.2 ohms	3.6 ohms.
Resistance of NW winding (80° F. ambient temperature) serial numbers 1 to 40, inclusive	1.7 ohms	2.7 ohms.
Resistance of NW winding (80° F. ambient temperature) serial numbers 41 and above	2.2 ohms	3.6 ohms.

(3) The arrow labeled "Fore" should *not* point forward for intercardinal mounting but should point toward the starboard bow, 45° from the center line. The arrow should point forward *only* when the coil unit is cardinally mounted.

Part 7—TYPE "TE"

6–71. DESCRIPTION

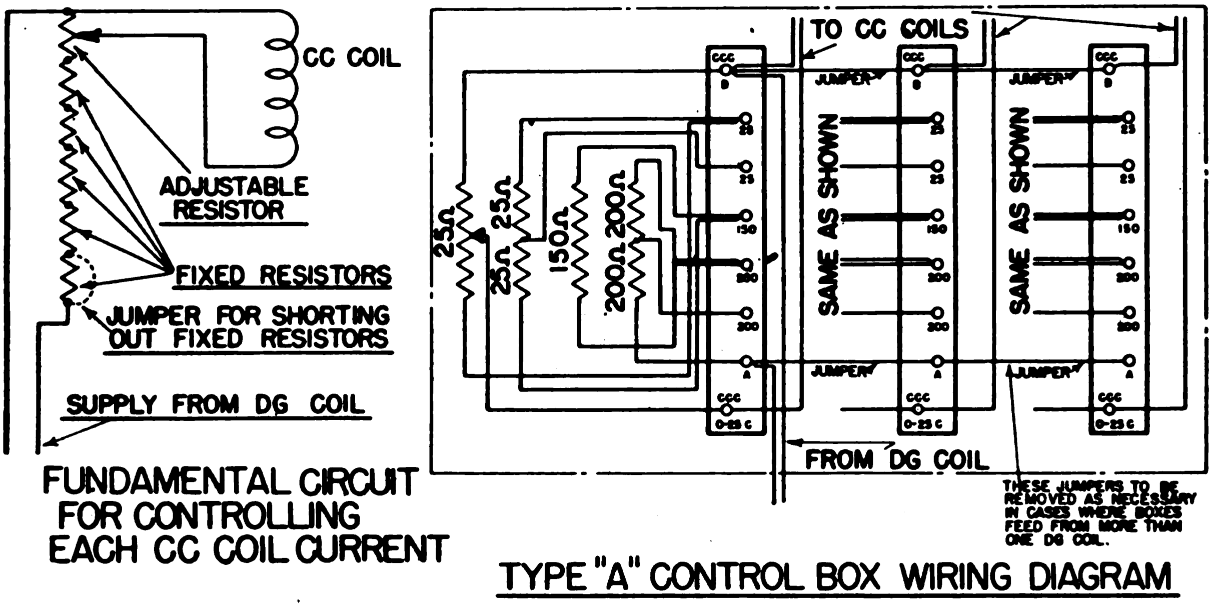
The type "TE" compass compensating coil (when it becomes available) will be used to compensate a new six-inch compass of lightweight design. The type "TE" compass compensating coil assembly is a single unit with three coils (a circular heeling coil, a rectangular B coil, and a rectangular C coil) cast in a plastic material. It is expected that this unit will become available about June 1953.

Section 3—INSTALLATION OF CONTROL BOXES

Part 1—TYPES OF CONTROL BOXES

6–81. TYPE "A"

(1) The type "A" control box is shown mounted at the base of the binnacle in fig. 6–10. The type "A" control box, usually called the A box, is the only type of control box now in use. It consists of a watertight enclosure having a removable cover and containing three sets of control resistors readily accessible for compensation. Each set of control resistors consists of fixed resistors in series with a variable resistor, the entire set being connected across the supply leads from the degaussing coil as shown in fig. 6–25. Part or all of the series resistors


CC COIL
ADJUSTABLE RESISTOR
FIXED RESISTORS
JUMPER FOR SHORTING OUT FIXED RESISTORS
SUPPLY FROM DG COIL
FUNDAMENTAL CIRCUIT FOR CONTROLLING EACH CC COIL CURRENT
TO CC COILS
CCC
B
JUMPER
25
150
200
A
0-25 C
25Ω
150Ω
200Ω
SAME AS SHOWN
FROM DG COIL
THESE JUMPERS TO BE REMOVED AS NECESSARY IN CASES WHERE BOXES FEED FROM MORE THAN ONE DG COIL.
TYPE "A" CONTROL BOX WIRING DIAGRAM

TOTAL RESISTANCE OF BANK MAY BE VARIED BY FOLLOWING MEANS:
(1) SLIDER ON ADJUSTABLE RESISTOR
(2) SHORT OUT FIXED RESISTORS AT TERMINAL STRIP
(3) CONNECT RESISTORS IN PARALLEL

Figure 6–25 Type "A" control box wiring diagram.

are jumped out, using jumpers supplied with the A box, and the variable resistor is adjusted to regulate the compass compensating coil current to the value required for compass compensation.

(2) Since the magnetic field produced by a degaussing coil is seldom in line with any of the compass compensating coil axes, it is unusual for any component to be zero, and it is normally necessary to compensate for all three components of the magnetic field produced at the compass by each degaussing coil. This requires three control circuits, hence, one A-box, for each degaussing coil that requires compensation. The three circuits in the A box are connected in parallel across the leads from the degaussing coil. One circuit is used for compensating the vertical component, the other two for compensating the two horizontal components, cardinal or intercardinal, depending upon how the compass compensating coils are mounted.

6-82. TYPE "A-1"

The type "A-1" control box will be a unit with a six lug enclosure similar to the type "A" box but with an improved resistor assembly. This box is not now available but is expected to be by January 1953.

Part 2—INSTALLATION

6-91. LOCATION

(1) *Places to be avoided.* Never locate a control box where it is exposed to the weather. The location chosen should be dry and accessible for periodic checks on resistor settings. Avoid shower rooms, galleys, refrigerator compartments, and Commanding Officer's and Executive Officer's cabins.

(2) *Binnacle.* The control boxes should be located at the base of the binnacle if the compass is *not exposed to the weather.* Proximity to the compass eliminates any need for a connection box between the control box and the compass compensating coil, and facilitates observation of the compass card when the resistor settings are changed. The control boxes should be so located on the binnacle that they do not obstruct passageways.

(3) *Noncombatant vessels and merchant ships.* On these vessels, readily accessible space for control boxes is usually available on bulkheads in the pilot house or chart house. The compass coil cable should be brought beneath the deck to a connection box and the run to the control boxes completed using a single multiconductor armored cable. If cable with nonmagnetic armor is not available, magnetic armor should be stripped away from the cable within the magnetic circle.

(4) *Combatant naval vessels.* On combatant naval vessels where space in the pilot house or chart house is at a premium and control boxes cannot be mounted on the pedestal, or where no pedestal exists, it will be necessary to mount the boxes on the overhead or bulkhead of the pilot house or chart house, or on the overhead of the compartment directly beneath the compass.

(5) *Control boxes for type "T" coils.* Control boxes for the type "T" compass coils used with magnesyn compasses can sometimes be located in sheltered positions beneath platforms on or near the mast. When the 25-foot length of MHFF cable supplied with type "T" coils is too short to permit installing the control boxes in a sheltered location, replace the cable with a longer type MHFF cable rather than install a connection box. Make sure that adequate voltage is available at the type "T" coil when leads longer than 25 feet are used. In no case should a control box be installed closer than 18 inches from the magnesyn transmitter.

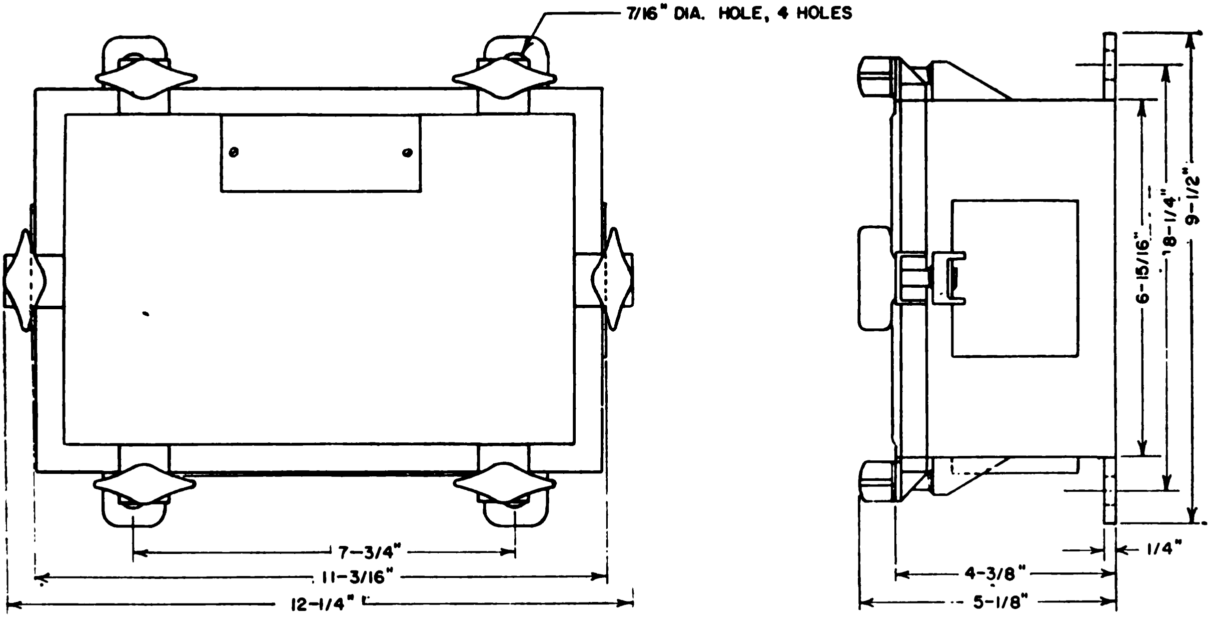
(6) *Connection box.* When control boxes are located at a distance from the binnacle of the compass with which the control boxes are used, the MDGB-12 (1½) cable leads from types "K-1", "K-2", "Filled K", and "R-1" coils should end at a connection box which may be mounted at the base of the binnacle. If a nonmagnetic connection box is not available, the MDGB-12 (1½) cables may be run directly to control boxes beneath the deck provided that the cables from the compass compensating coils are long enough and provided also that the cables are adequately protected by a kick pipe assembly above deck and conduit below deck. Conduit, fittings, and other materials installed within the magnetic circle should be nonmagnetic.

(7) *Communication for adjusting.* If permanently installed facilities for communication to the compass are not available where the control boxes are located, it may be necessary to use a portable telephone set carried by the compass adjusters in order to adjust the control box settings. Care should be exercised when using a portable telephone set near the compass because such sets are usually strongly magnetic.

(8) *Steel enclosures.* Future procurement plans for compass compensating control boxes include resistor assemblies with steel enclosures. These enclosures will be adequately marked to indicate that they are made of magnetic material. The boxes *should not* be mounted within the ship's nonmagnetic circle.

6-92. MOUNTING

(1) *Mark VII binnacle.* The Mark VII binnacle for Navy, Standard No. 1 compass requires special mounting straps for the control box to be made up by the installing activity. Fig. 6-26 gives the mounting dimensions for the enclosure of the control box and fig. 6-27 gives suggested arrangements for the mounting straps when one or two control boxes are



MOUNTING DIMENSIONS
COMPASS COMPENSATING CONTROL BOX

TYPE "A"

Figure 6-26 Mounting dimensions of compass compensating control box.

used. Fig. 6-27 also illustrates straps for mounting three control boxes at the base of the binnacle. When four control boxes are needed, straps should be designed by the installing activity to suit the clearances around the particular binnacle concerned, taking into consideration the precautions given in art. 6-94.

(2) *Navy standard plywood pedestal.* A suggested arrangement for mounting control boxes on the Navy standard plywood pedestal for shelf type binnacles is shown in fig. 6-28.

(3) *Merchant binnacles.* These should be fitted with mounting straps similar to those for the plywood pedestal, but having dimensions to suit the particular binnacle concerned.

6-93. TERMINAL TUBES AND INTERCONNECTING PIPES

(1) *Cable entrance.* The control boxes must be drilled for cable entrances by the installing activity. Normally there is one supply cable containing supply leads from all degaussing coils affecting the compass, interconnecting pipes between control boxes, and at least two flexible cables from the control boxes to the compass coils. All these holes are drilled in the side or bottom of the box through the pads on the box. *No holes should be drilled through the top of a box* unless it is necessary to mount one control box above another. In this case, the pipe nipple entering the top of the box must be brazed into the top of the box. The cover of the box and the cover gasket must be removed before the brazing is done to prevent deterioration of the gasket by the brazing temperature. It is *preferable to braze all pipes and fittings in place,* particularly those for supply leads and interconnecting leads. This is not always feasible, and some holes must be drilled and tapped. Special attention must be given to these to make sure that they are watertight. A block should be used inside the box whenever holes are drilled to support the face being drilled and prevent distortion that would keep the cover from seating properly.

(2) *Packing.* Make sure that any packing used will not act as a wick to draw water into a box.

(3) *Drainage.* Provide facilities for draining water from the lowest point of each control box. If the lowest point is an interconnecting pipe, a pipe plug or pipe flange should be installed for drainage.

(4) *Test for watertight integrity.* The installation should not be considered complete until checked for watertight integrity at all joints and at the cover gasket, perferably by applying not more than 5 psi internal air pressure at the test plugs on the end pad of the control box.

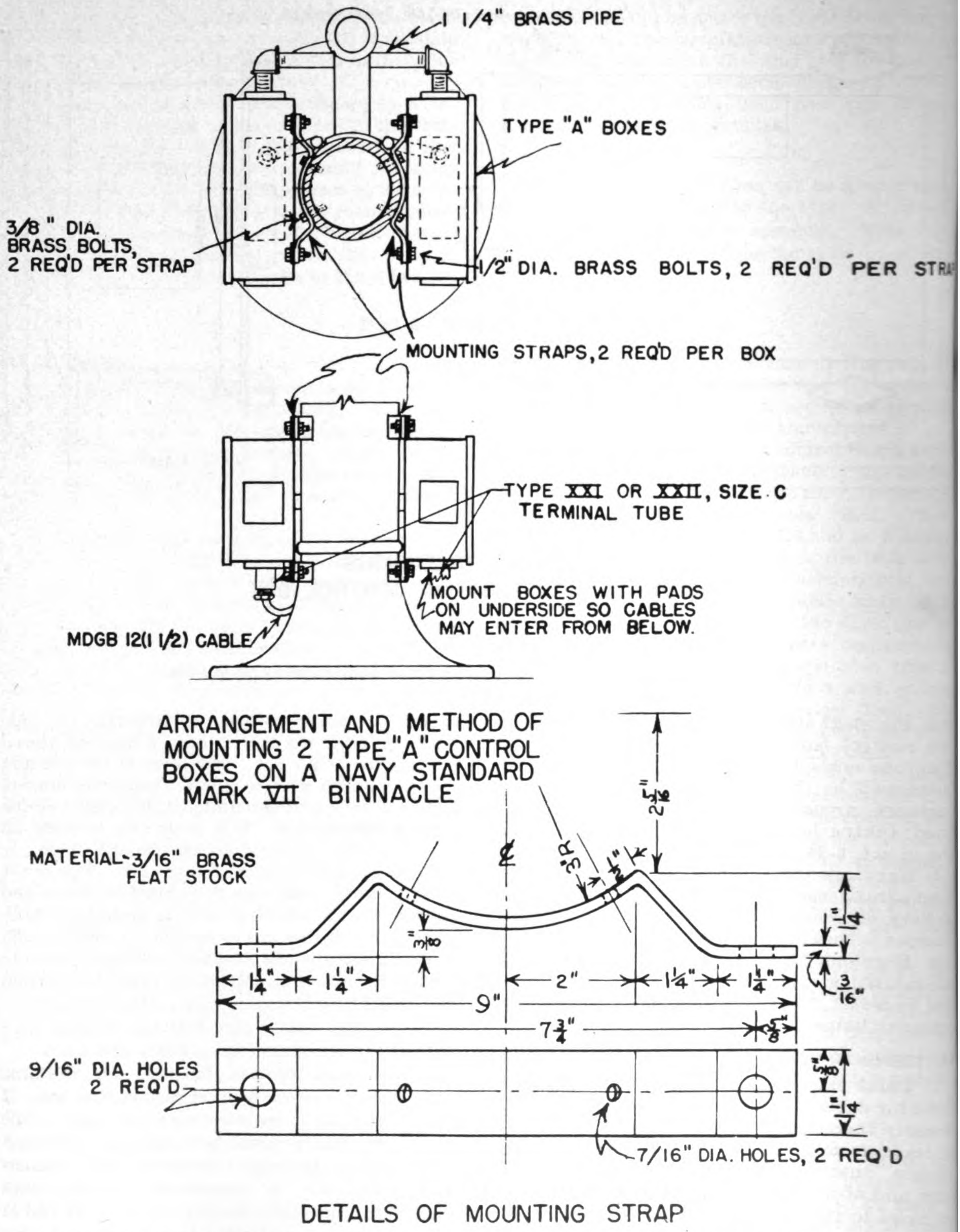
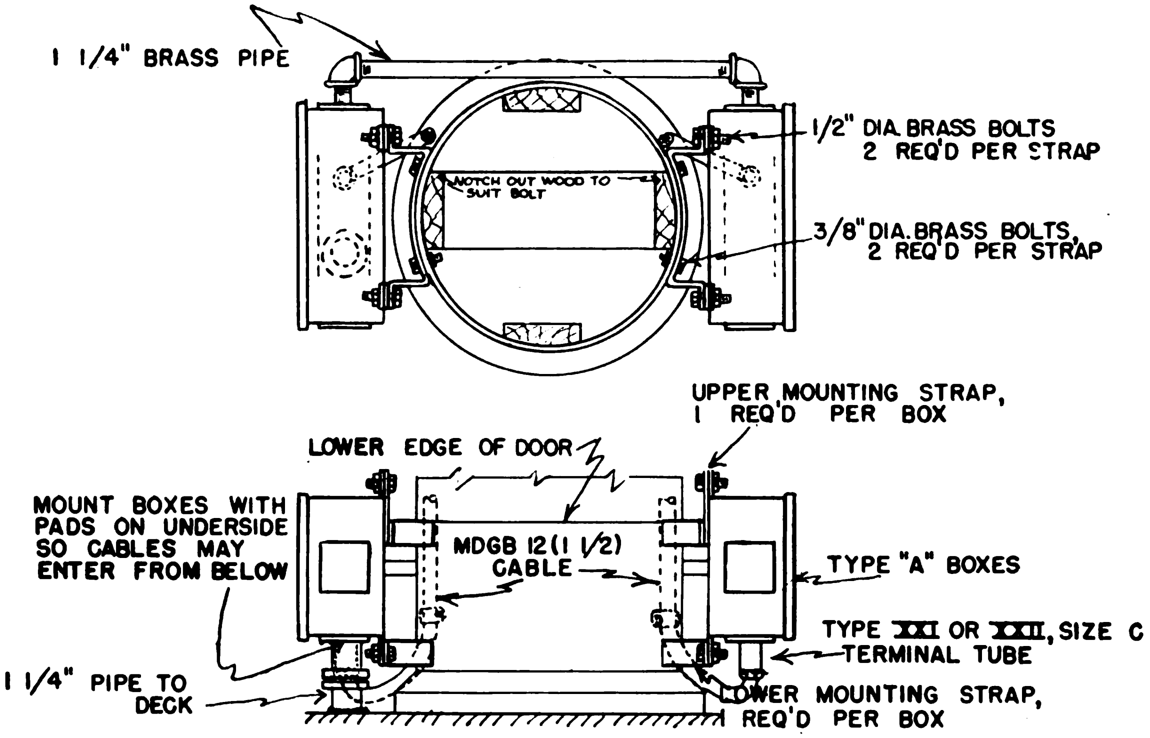
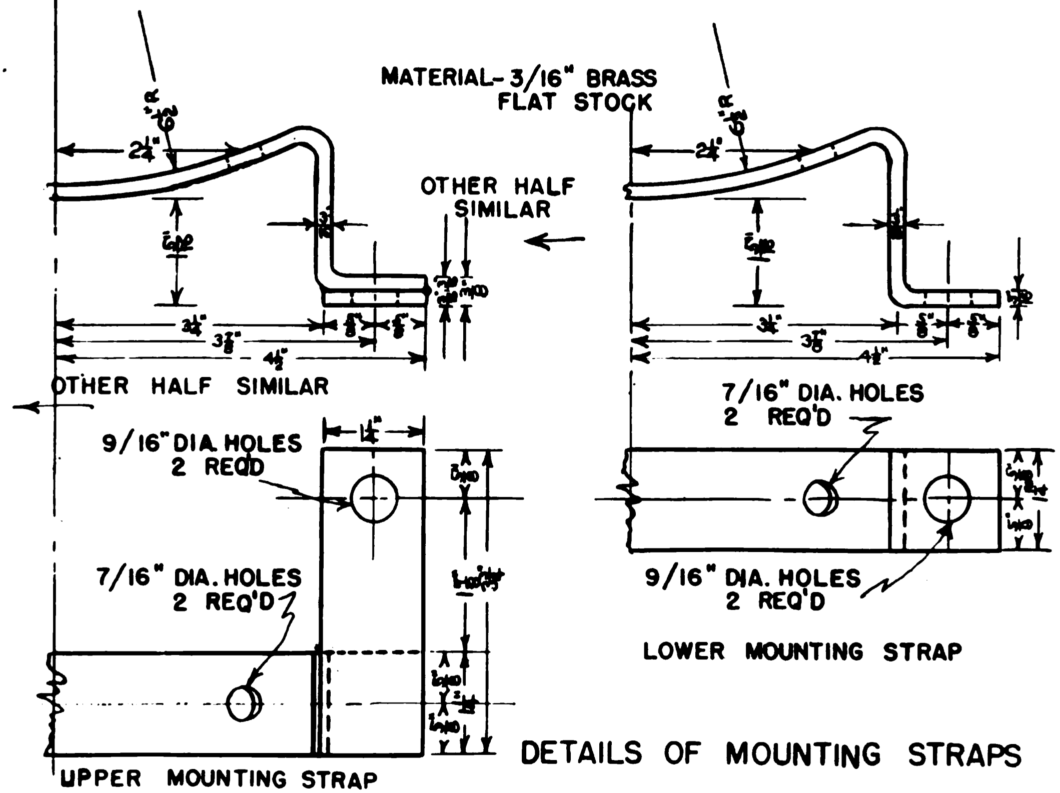

1 1/4" BRASS PIPE
TYPE "A" BOXES
3/8" DIA. BRASS BOLTS, 2 REQ'D PER STRAP
1/2" DIA. BRASS BOLTS, 2 REQ'D PER STRA
MOUNTING STRAPS, 2 REQ'D PER BOX
TYPE XXI OR XXII, SIZE C TERMINAL TUBE
MOUNT BOXES WITH PADS ON UNDERSIDE SO CABLES MAY ENTER FROM BELOW.
MDGB 12(1 1/2) CABLE
ARRANGEMENT AND METHOD OF MOUNTING 2 TYPE "A" CONTROL BOXES ON A NAVY STANDARD MARK VII BINNACLE
MATERIAL-3/16" BRASS FLAT STOCK
2 5/16"
3"R
3/4"
℄
3/16"
1 1/4"
3/16"
1 1/4"
1 1/4"
2"
1 1/4"
1 1/4"
9"
7 3/4"
5/8"
5/8"
1 1/4"
9/16" DIA. HOLES 2 REQ'D
7/16" DIA. HOLES, 2 REQ'D
DETAILS OF MOUNTING STRAP

Figure 6–27. Arrangement and method of mounting two type "A" control boxes on a Navy standard **Mark VII** binnacle.


1 1/4" BRASS PIPE
1/2" DIA. BRASS BOLTS 2 REQ'D PER STRAP
NOTCH OUT WOOD TO SUIT BOLT
3/8" DIA. BRASS BOLTS, 2 REQ'D PER STRAP
UPPER MOUNTING STRAP, 1 REQ'D PER BOX
LOWER EDGE OF DOOR
MOUNT BOXES WITH PADS ON UNDERSIDE SO CABLES MAY ENTER FROM BELOW
MDGB 12(1 1/2) CABLE
TYPE "A" BOXES
TYPE XXI OR XXII, SIZE C TERMINAL TUBE
1 1/4" PIPE TO DECK
LOWER MOUNTING STRAP, REQ'D PER BOX

ARRANGEMENT AND METHOD OF MOUNTING 2 TYPE "A" CONTROL BOXES ON A NAVY STANDARD PLYWOOD PEDESTAL



DETAILS OF MOUNTING STRAPS

Figure 6–28. Arrangement and method of mounting two type "A" control boxes on a Navy standard plywood pedestal.

6–94. INSTALLATION PRECAUTIONS

(1) Choose locations for control boxes carefully. See art. 6–91.

(2) *Joints must be watertight.* A great deal of maintenance and replacement trouble can be avoided by making sure joints are watertight.

(3) *Do not distort the body of a control box.* If mounting lugs do not fit mounting brackets exactly, provide shims or rebend the mounting brackets to make a good fit. Make sure the cover fits freely on the body with no binding at the cover gasket channel.

(4) Do not mount control boxes closer than 18 inches from the compass, or less than 4 inches above the deck.

(5) When it is necessary to mount control boxes away from the binnacle, the cable runs between the compass coils and control boxes are normally run in brass pipe. No magnetic cable armor or conduit should be used within the magnetic c cle for fixed magnetic materials. The flexible ca from the coils should be protected from abras above deck by a kick-pipe assembly welded wate tight at the hole through the deck, and should protected below deck by nonmagnetic conduit. T cable length between compass coils and A bo should not exceed 25 feet. When the cable ru made above deck, it should not present a tripp hazard or become a barrier in a passageway. F ible cables between control boxes and compass c should be short and adequately protected.

(6) Do not install more control boxes than a needed, particularly for magnesyn compasses wh the height at which the control boxes are insta makes extra weight particularly undesirable.

(7) Securely *ground* each control box and the ca of each compass coil.

Section 4—ELECTRICAL CONNECTIONS AND CONDUCTOR MARKINGS

6–101. POWER SUPPLY

(1) *Methods.* The voltage applied to the compass compensating coils must be proportional to the degaussing coil current in order to compensate for all values of degaussing coil current. To accomplish this, the voltage drop across either a resistance in series with the degaussing coil, or across a part of the degaussing coil, or across the whole degaussing coil is used for the compass compensating coil power supply. Fig. 6–29 illustrates arrangements used for compass compensating coil power supply.

(2) *Supply leads.* Separate power supply leads should be run from the source of power supply for the compass compensating coils to the control box for each compass which is compensated. If there are two compasses, for example, separate cables can be run from the source of power to the two compasses. An alternative arrangement is to run a single multiconductor cable from the source of power supply to a connection box near both compasses, use two conductors in the cable for the power supply leads for one compass, two different conductors for the power supply leads for the other compass, and then continue from the connection box with two separate cables, one running to each compass. In no case shall the arrangement used be such that any conductor in the power supply leads carries current for more than one compass. The power supply leads are connected to the control box terminals marked "A" and "B". Type MHFA cable with the required number of conductors and having at least two spare conductors should be used for compass coil power supply leads for naval vessels and MDGD–3 or MDGD–7 cable for merchant vessels. If the installation can be simplified, it is permissible to include leads to remote ammeters

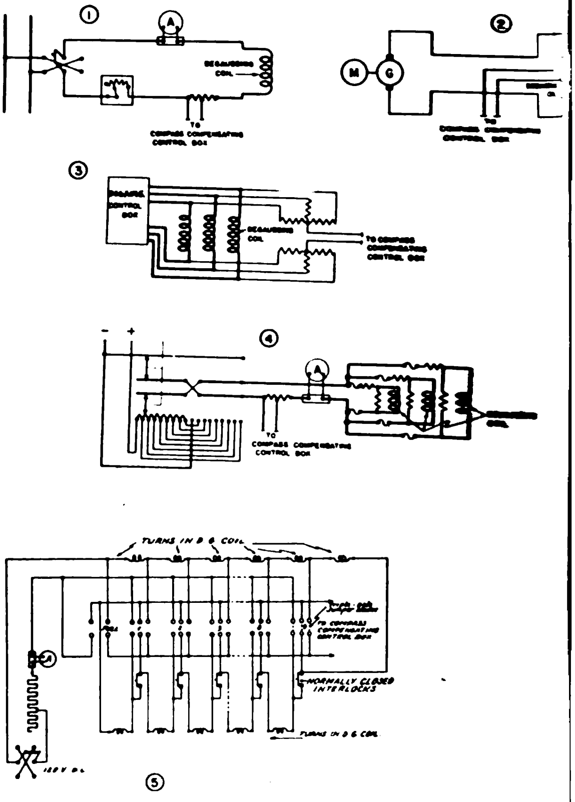

①
A
DEGAUSSING COIL
TO COMPASS COMPENSATING CONTROL BOX
②
M
G
③
④
A
TO COMPASS COMPENSATING CONTROL BOX
⑤
TURNS IN D G COIL
NORMALLY CLOSED INTERLOCKS

Figure 6–29 Compass compensating coil power supp systems.
1. Typical merchant M coil.
2. Cruiser F coil.
3. Destroyer M coil. This resistor network is seld used any more.
4. Destroyer multiple-circuit M coil.
5. LA 2470 control box for patrol craft M coil.

or indicator lights in the same cable with compass coil power supply leads, but a-c leads and circuits associated with a system other than degaussing should not be run in the power supply cable.

(3) *Voltage.* The most desirable range for the compass compensating coil supply is 6 to 10 volts. Lower voltage may be used, however, particularly if the currents required by the compass coil windings are small. Higher voltages are not desirable but may be used provided the resistance units in the control box are not overloaded.

(4) *Fuses.* No fuses are used in compass compensating circuits. The reason is to make a fault in the circuits immediately obvious by erratic or obviously incorrect compass readings. Blown fuses might not be detected immediately and might lead to serious errors in navigation.

6–102. WIRING

(1) *Completion.* Compass coil, control box, and supply lead wiring on new construction vessels should be as nearly completed as practical at the building yard. Since the control box wiring cannot be completed until the normal adjustment is made, usually not until after the completion of the vessel, it is desirable for the building yard to duplicate the wiring (correct supply volts, right number of resistor units jumpered out, right polarity, etc.) used on similar previous vessels of the same class.

(2) *Cable.* Cable leads to types "K–1", "K–2", "Filled K", "R–1", "R–2", "T", and "TE" coils are furnished with the coils. The type MDGB–12 (1½) cable used with types "K–1", "K–2", "Filled K", "R–1" and "R–2" coils is standard Navy degaussing cable. The MHFF–19 cable used on the type "T" coils is a standard Navy cable and can be obtained from stock. Type MDGB–12 (1) cable, which is used in the wrap-around type "A" heeling coils, should not be used for coil leads. Watertight, type MDGB–12 (1½) cable may be used for nearly any compass coil cable requirement provided the proper size packing glands are furnished. Cable should not be taped to fit the wrong size packing gland. Nonwatertight MDGB–12 (1½) cable should not be used.

(3) *Control box wiring.* Wires in the control box should be heat- and flame-resistant, when possible. If, as in the case of MDGB (1½) cable, the conductors are insulated with synthetic resin, a suitable flame-resistant spaghetti (such as fiber glass tubing) should be slipped over each conductor that runs close to a resistor.

(4) *Wiring accessories.* Nonmagnetic cable clips, cable armor, screws, bolts, fittings, etc., should be used within the magnetic circle. Cable clips are furnished with types "K–1," "K–2," and "Filled K" coils but should be fabricated and supplied by the installing yard for all other type coils. If the only cable available has magnetic armor, the armor should be stripped back the required distance and the cable should be otherwise protected from abrasion, if necessary.

6–103. TAGS

Suitable tags should identify each conductor in the control box and in any junction boxes in the supply leads. Identification tags are furnished with types "K–1," "K–2," "Filled K," "R–1," "T," and "TE" coils. A small stock of designation plates for identifying control circuits in the control box is available at each degaussing station. Additional quantities should be fabricated or procured locally. The tags should be nonmagnetic, corrosion proof, waterproof, and of a construction to prevent cracking and breaking in service. All tags other than those furnished with control boxes and coils are to be furnished by the installing activity.

6–104. MARKING

The letters before the dash in the following letter combinations give the component of magnetic field compensated, H, B, C, NE, or NW, and the letters after the dash give the degaussing coil which produces the field that is compensated. A designation plate bearing the appropriate symbol should be screwed to the terminal strip of each control circuit used.

H–M	B–M	C–M	NE–M	NW–M
H–I	B–I	C–I	NE–I	NW–I
H–P	B–P	C–P	NE–P	NW–P
H–A	B–A	C–A	NE–A	NW–A
H–F	B–F	C–F	NE–F	NW–F
H–Q	B–Q	C–Q	NE–Q	NW–Q
H–Maux	B–Maux	C–Maux	NE–Maux	NW–Maux
H–L	B–L	C–L	NE–L	NW–L

Control boxes are equipped with name plates having a blank space for the degaussing coil designation. It is important that this name plate be engraved or clearly scribed with the correct degaussing coil symbol (or both symbols if the control box contains circuits for two degaussing coils) at the time of installation so that compensation or trouble shooting at a later date will not necessitate entrance to any other than the box desired. Supply leads from a particular degaussing coil, say the M coil, are connected to the terminals marked A and B in the M control box. Compass coil leads for the H, B, and C windings compensating the M coil, or the H, NE, and NW windings, are each connected to a separate pair of terminals labeled "CCC" in the M control box.

6–105. WIRING DIAGRAMS

(1) A wiring diagram for intercardinally mounted coils is shown in fig. 6–30. References are given to additional wiring diagrams in art. 6–161.

(2) Another wiring diagram for compass coils is shown in fig. 6–31. References are given to additional wiring diagrams in art. 6–161.

(3) The type "A" control box wiring diagram is shown in fig. 6–25.

Section 5—COMPASS COMPENSATION

Part 1—GENERAL

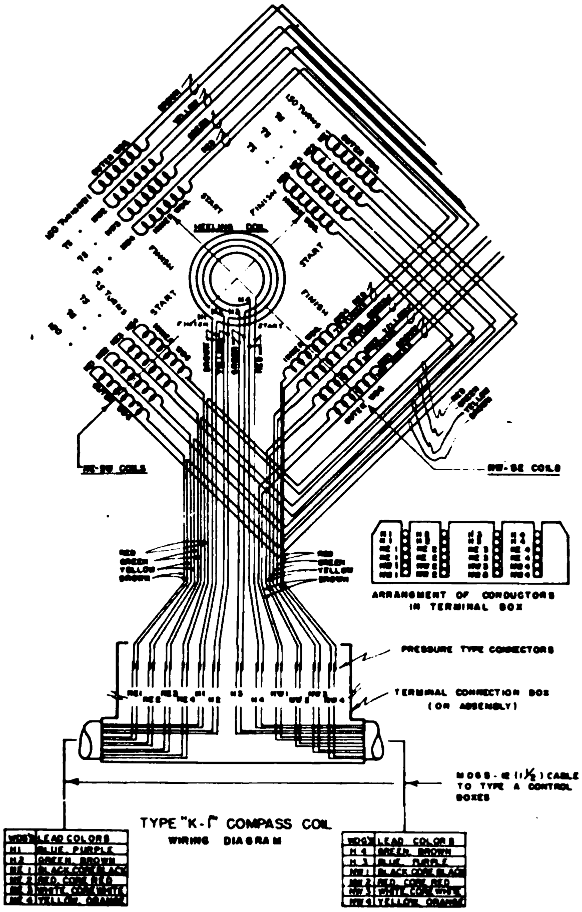


Figure 6–30. Type "K–1" compass compensating coil wiring diagram.

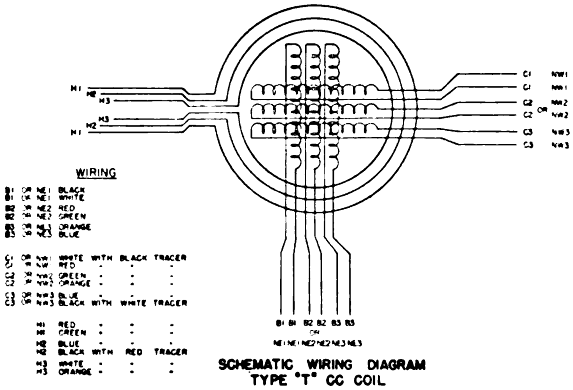


Figure 6–31. Type "T" compass compensating coil wiring diagram.

6–111. DEFINITIONS AND PRINCIPLES

Degaussing compass coil compensation consists of regulating the current in the compass compensating coils so that there is no change in magnetic field at the compass needles when the degaussing coil is energized or the degaussing coil current is changed. The regulation is accomplished by means of control resistors in the control boxes. The resistors and compass compensating coil circuits are so connected that for fixed resistor settings the compass compensating coil field automatically varies with and is proportional to the degaussing coil field at the compass, hence, no adjustment of the resistors is necessary when the degaussing coil current is changed. Each compass compensating coil winding is controlled by a separate resistor network in the control box as illustrated by the wiring diagram of fig. 6–25.

6–112. STEPS INVOLVED

(1) *Compensation—general term.* The general term "compensation" includes the three following distinct steps or procedures:

(a) A preliminary or "dockside" compensation.
(b) A "final" compensation.
(c) A swing for deviations.

(2) *Dockside compensation.* The dockside compensation is a preliminary compensation which is usually made soon after the degaussing system is installed and tested. The dockside compensation is made while the ship is moored. The compass is deflected by means of permanent magnets, and then, with one degaussing coil at a time turned on, the appropriate control resistor is adjusted so that the compass error caused by the degaussing coil is a minimum.

(3) *Final compensation.* The final compensation is made in the harbor or "swinging area" upon completion of normal compass compensation (magnets, spheres, etc.) with the ship away from dockside disturbances and is a refinement of the dockside compensation. The final compensation is made by placing the *ship* on the desired heading and then, with one degaussing coil at a time turned on, adjusting the appropriate control resistor so that the compass error caused by degaussing is a minimum. Both the dockside and the final compensations should be made only by qualified adjusters.

(4) *Swing for deviations.* Immediately following the final compensation, the ship is swung to determine compass deviations.

6–113. HEADINGS USED FOR COMPENSATION

(1) *Cardinal mounting.* Cardinally mounted compass coils are compensated on cardinal headings, that is, with the compass reading N or S for

compensating the C component, and E or W for compensating the B component. For these headings, the compass *needles* are perpendicular to the component of degaussing coil magnetic field which is being compensated.

(2) *Intercardinal mounting.* Intercardinally mounted compass coils are compensated on intercardinal headings, that is, with the compass reading NE or SW for compensating the NE component, and NW or SE for compensating the NW component. Note that the headings used are such that the compass *needles* are perpendicular to the component of degaussing coil magnetic field which is being compensated.

(3) *Heeling coil.* The heeling coil for either cardinally or intercardinally mounted coils can be compensated on any heading.

6–114. PRECAUTIONS

In both the dockside and the final compensation, care must be taken to see that the safe currents of resistors and coils are not exceeded.

(1) *Resistors.* The resistors in the type "A" control box may be connected in various parallel and series combinations provided that the maximum currents do not exceed:

25-ohm variable resistor	1.41 amperes.
50-ohm fixed resistor	1.00 ampere.
150-ohm fixed resistor	.58 ampere.
400-ohm fixed resistor	.35 ampere.

The total heat dissipation for all resistors in a control box should not exceed 55 watts so that the box temperature will not be excessive.

(2) *Coils.* The maximum current in any one winding of a coil should not exceed the value given below:

Type of coil	Maximum current (amperes)
Type "A"	1.4
Types "B" and "B Mod."	1.4
Types "C" and "C Special"	1.4
Type "G" and "G Mod"	1.4
Types "K", "K-1", "K-2" and "Filled K":	
NE and NW coils	1.4
Heeling coil	2.0
Type "R-1"	1.0
Type "R-2"	1.0
Type "T"	1.0
Type "TE"	1.0

Part 2—DOCKSIDE COMPENSATION

6–121. DEGAUSSING COIL CURRENT

The maximum degaussing coil currents (values specified in the ship's degaussing folder) should be used for making the dockside compensation.

6–122. CONDITIONS FOR DOCKSIDE COMPENSATION

(1) *Safety.* The maximum degaussing coil currents which are used during dockside compensation are not the coil currents which are correct for proper degaussing of the ship at the place where the compensation is made and the heading of the ship during compensation. It is, therefore, essential that the dockside compensation be made only in waters which are known to be free from magnetic mines.

(2) *Magnetic disturbances.* Local magnetic disturbances such as those caused by moving cranes, moving vessels alongside, arc welding, etc., may impair the accuracy of dockside compensation, hence, dockside compensations should be made, if possible, when the disturbances are a minimum, such as during the noon hour or at changes of shifts.

(3) *Normal compass adjustment.* Better dockside compensation will result if the compass is in good normal adjustment. If the compass is not in good normal adjustment, normal adjustment should be at least approximated. If normal adjustment, or a partial adjustment cannot be made, the dockside compensation should be made nevertheless, since, even under poor conditions the dockside compensation gives a check on correct voltage supply, electrical connections, and polarities of windings. When the dockside compensation is made under good conditions, good normal adjustment of the compass, and freedom from local magnetic disturbances, only slight resetting of the control resistors is required in the final compensation.

6–123. COMPENSATION OF H COMPONENT

The H component should be compensated first, then the horizontal components. The following procedure should be used for compensating the H component, both for cardinally and intercardinally mounted compass coils:

(1) Start with all degaussing coil currents set at their maximum value and then reduce all coil currents to zero by the method of reversals described in art. 6–129.

(2) Remove the compass and put a calibrated dip needle in place of the compass. For model A magnesyn transmitters the dip needle pivot should be centered ¾″±⅛″ above the top of the type "T" compass coil flange. For model B magnesyn transmitters the distance should be 3″±⅛″. For other type compasses, center the dip needle at the level of the compass card. Adjust the weight on the dip needle to make the needle horizontal. If the weight on the dip needle was previously set for normal compass adjustment and it is desired not to disturb this setting, level the needle by raising or lowering the heeling magnet, *but make sure that the heeling magnet is restored to its correct position after compensating the H component of degaussing coil field.* In certain cases (as with the T coil) it may not be convenient to replace the compass with a dip needle. Under these conditions

other provisions such as placing the dip needle to one side of the compass compensating coil at a predetermined location may be necessary.

(3) Energize one degaussing coil with its maximum current and note any dip of the needle. If the needle does not dip, operations (4) and (5) are not necessary.

(4) Increase or decrease the current in the heeling coil circuit for the degaussing coil which is energized in order to make the dip needle return to its original position. This may necessitate shorting out or adding fixed resistance as well as adjusting the variable resistor, or it may require reversing the compensating coil leads. To see whether the heeling coil leads need reversing, note the dip with and without the heeling coil in the circuit. The heeling coil leads should be reversed if the needle dips more in the same direction when the heeling coil is in the circuit.

(5) Check the current through the compass compensating coils and the variable and fixed resistors of the control box to make sure that the current in each circuit element does not exceed the current rating of the element.

(6) Reduce the degaussing coil current to zero and then increase to the maximum value in the opposite direction. Note any dip in the needle, other than a momentary dip, and make any further adjustments necessary.

(7) Reduce the degaussing coil current to zero by the method of reversals (see art. 6–129).

(8) Repeat operations (3) to (7) for each degaussing coil.

(9) Record the compensation data, as it is taken, on NAVSHIPS 2525 (see fig. 6–32).

6–124. DEFLECTING THE COMPASS FOR HORIZONTAL COMPONENTS

(1) *Reason for deflecting.* The heading of the ship is not changed during a dockside compensation. Instead of this, a suitable arrangement of deflector magnets is employed to deflect the compass to the reading specified in art. 6–124 (2), and to approximate at the compass the strength and direction of the magnetic field that would be present if the ship were placed on the heading which corresponds to the compass reading.

(2) *Procedure for deflecting.* To deflect the compass by means of a permanent magnet (or a bundle of magnets), the deflecting magnet is placed with the longitudinal axis perpendicular to the imaginary vertical plane which bisects the angle between the original direction of the compass needle and the desired direction. The magnet may be placed either above (preferred), to the side, or below the compass, provided the axis of the magnet is perpendicular to the bisecting plane. The desired compass heading is obtained by moving the magnet closer to or farther from the compass. Fig. 6– illustrates this method of deflecting the compass. It is essential that this procedure for deflecting the compass be used so that the directive force at the compass will be maintained for the new heading.

6–125. COMPENSATION OF B AND C COMPONENTS

(1) *Cardinal mounting.* For cardinally mounted compass compensating coils, the horizontal components which are compensated are the B and C components.

(2) *Order of compensation.* The larger component should be compensated first.

(3) *Compensation of B component.* The procedure given below should be followed for setting the B coil control resistors to compensate the B component.

(a) Replace the dip needle with the regular compass.

(b) Deflect the compass to a 90° or 270° reading by the procedure given in art. 6–124 (2).

(c) Energize one degaussing coil with its maximum current and note the compass deflection. If the compass does not deflect, steps (d) and (e) are not necessary for this degaussing coil.

(d) Increase or decrease the current in one of the B windings to make the compass return to the reading obtained in step (b). This may require shorting out or adding fixed resistors as well as adjusting the variable resistor in the control box and it may also require reversing the compensating coil leads. To see if the coil leads need reversing, note the compass deflection with and without the compensating coil in the circuit. Reverse the compass coil leads if the deflection with the coil in the circuit is greater than but in the same direction as the deflection without the coil in the circuit.

(e) Check the current through the coils and the fixed and variable resistors in the control box to make sure that the current in each circuit element is no greater than the rating of the element.

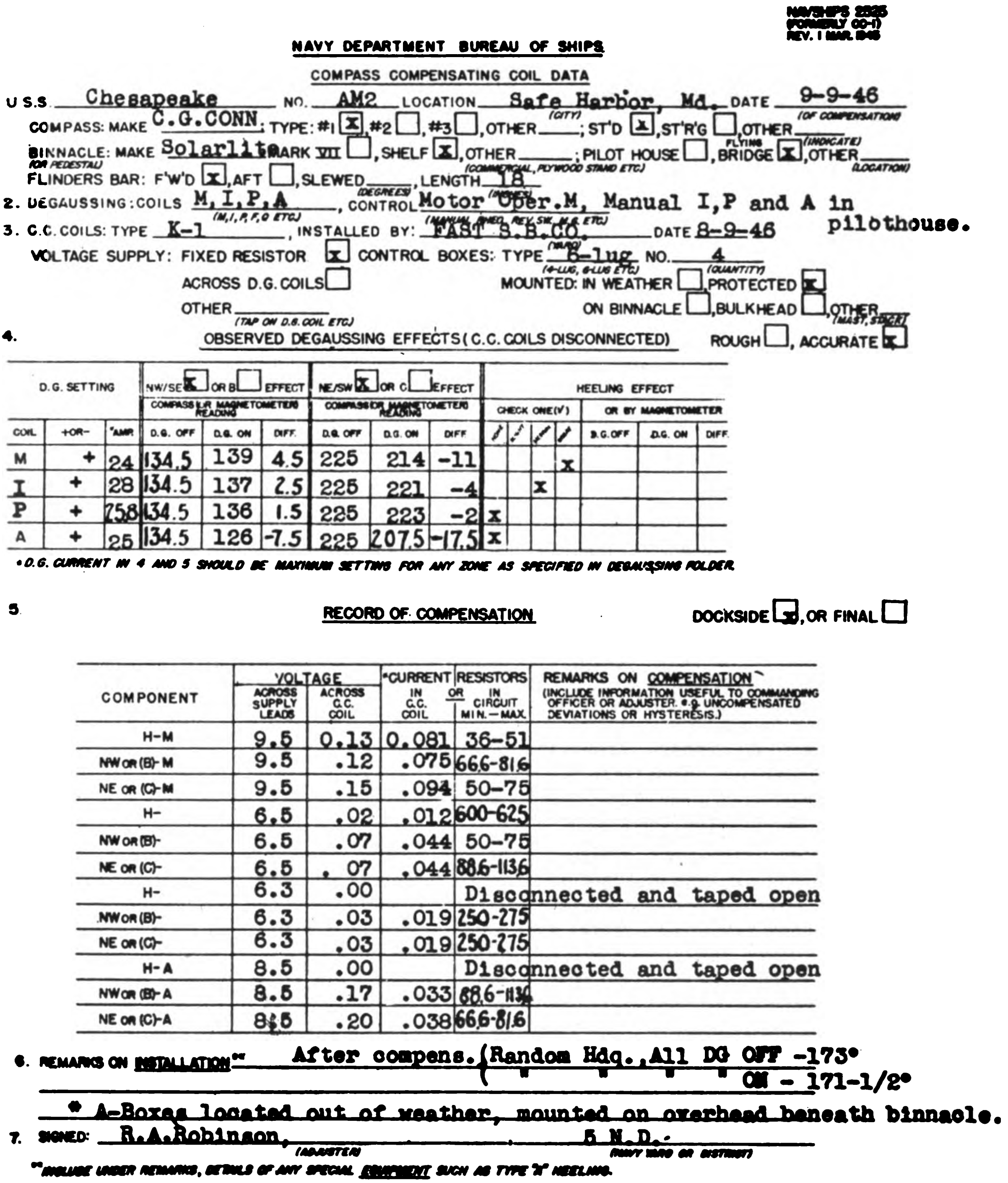
(f) Reduce the degaussing coil current to zero and then increase to a maximum in the other direction. Note any deviations and make any refinements necessary.

(g) Reduce the degaussing coil current to zero by reversals (see art. 6–129).

(h) Repeat steps (c) to (g), inclusive, for each degaussing coil.

(i) Record the compass compensating data, as it is taken, on NAVSHIPS 2525 (see fig. 6–32).

(4) *Compensation of C component.* The procedure given above for compensation of the B component is repeated for compensation of the C component except that the compass is deflected in step (b) to a reading of 0° or 180°.



NAVSHIPS 2525
(FORMERLY CC-1)
REV. 1 MAR. 1946

NAVY DEPARTMENT BUREAU OF SHIPS

COMPASS COMPENSATING COIL DATA

U.S.S. Chesapeake NO. AM2 LOCATION Safe Harbor, Md. (CITY) DATE 9-9-46 (OF COMPENSATION)

COMPASS: MAKE C.G.CONN; TYPE: #1 ☒, #2 ☐, #3 ☐, OTHER ____; ST'D ☒, ST'R'G ☐, OTHER ____ (INDICATE)

BINNACLE: MAKE (OR PEDESTAL) Solarlite MARK VII ☐, SHELF ☒, OTHER ____ (COMMERCIAL, PLYWOOD STAND ETC.); PILOT HOUSE ☐, FLYING BRIDGE ☒, OTHER ____ (LOCATION)

FLINDERS BAR: F'W'D ☒, AFT ☐, SLEWED ____ (DEGREES), LENGTH 18 (INCHES)

2. DEGAUSSING: COILS M, I, P, A (M, I, P, F, Q ETC.), CONTROL Motor Oper. M, Manual I, P and A in pilothouse. (MANUAL, RHEO, REV. SW., M.G. ETC.)

3. C.C. COILS: TYPE K-1, INSTALLED BY: FAST S.B.CO. (NAVY YARD) DATE 8-9-46

VOLTAGE SUPPLY: FIXED RESISTOR ☒ CONTROL BOXES: TYPE 8-lug (4-LUG, 6-LUG ETC.) NO. 4 (QUANTITY)

ACROSS D.G. COILS ☐ MOUNTED: IN WEATHER ☐, PROTECTED ☒

OTHER ____ (TAP ON D.G. COIL ETC.) ON BINNACLE ☐, BULKHEAD ☐, OTHER ____ (MAST, STACK)

4. OBSERVED DEGAUSSING EFFECTS (C.C. COILS DISCONNECTED) ROUGH ☐, ACCURATE ☒

D.G. SETTING			NW/SE ☒ OR B ☐ EFFECT			NE/SW ☒ OR C ☐ EFFECT			HEELING EFFECT						
			COMPASS (OR MAGNETOMETER) READING			COMPASS (OR MAGNETOMETER) READING			CHECK ONE (✓)				OR BY MAGNETOMETER		
COIL	+OR-	*AMP	D.G. OFF	D.G. ON	DIFF.	D.G. OFF	D.G. ON	DIFF.	/	/	/	/	D.G. OFF	D.G. ON	DIFF.
M	+	24	134.5	139	4.5	225	214	-11				x			
I	+	28	134.5	137	2.5	225	221	-4			x				
P	+	758	134.5	136	1.5	225	223	-2	x						
A	+	25	134.5	126	-7.5	225	207.5	-17.5	x						

*D.G. CURRENT IN 4 AND 5 SHOULD BE MAXIMUM SETTING FOR ANY ZONE AS SPECIFIED IN DEGAUSSING FOLDER.

5. RECORD OF COMPENSATION DOCKSIDE ☒, OR FINAL ☐

COMPONENT	VOLTAGE		*CURRENT OR RESISTORS		REMARKS ON COMPENSATION (INCLUDE INFORMATION USEFUL TO COMMANDING OFFICER OR ADJUSTER. e.g. UNCOMPENSATED DEVIATIONS OR HYSTERESIS.)
	ACROSS SUPPLY LEADS	ACROSS C.C. COIL	IN C.C. COIL	IN CIRCUIT MIN.—MAX.	
H-M	9.5	0.13	0.081	36-51	
NW OR (B)-M	9.5	.12	.075	66.6-81.6	
NE OR (C)-M	9.5	.15	.094	50-75	
H-	6.5	.02	.012	600-625	
NW OR (B)-	6.5	.07	.044	50-75	
NE OR (C)-	6.5	.07	.044	88.6-113.6	
H-	6.3	.00		Disconnected and taped open	
NW OR (B)-	6.3	.03	.019	250-275	
NE OR (C)-	6.3	.03	.019	250-275	
H-A	8.5	.00		Disconnected and taped open	
NW OR (B)-A	8.5	.17	.033	88.6-113.6	
NE OR (C)-A	8.5	.20	.038	66.6-81.6	

6. REMARKS ON INSTALLATION** After compens. (Random Hdg., All DG OFF -173°
(" " " " ON - 171-1/2°

* A-Boxes located out of weather, mounted on overhead beneath binnacle.

7. SIGNED: R.A.Robinson, (ADJUSTER) 5 N.D. (NAVY YARD OR DISTRICT)

**INCLUDE UNDER REMARKS, DETAILS OF ANY SPECIAL EQUIPMENT SUCH AS TYPE "X" HEELING.

Figure 6-32. NAVSHIPS 2525 form.

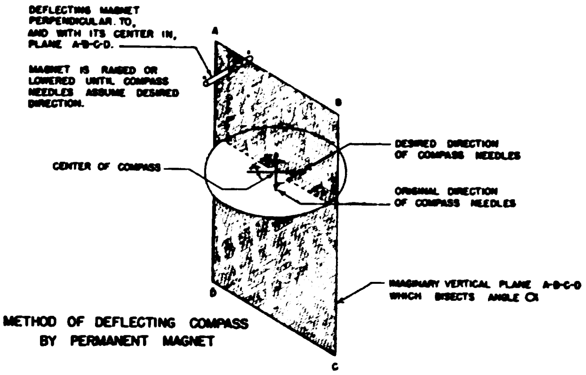

DEFLECTING MAGNET PERPENDICULAR TO, AND WITH ITS CENTER IN, PLANE A-B-C-D.
MAGNET IS RAISED OR LOWERED UNTIL COMPASS NEEDLES ASSUME DESIRED DIRECTION.
A
B
CENTER OF COMPASS
DESIRED DIRECTION OF COMPASS NEEDLES
ORIGINAL DIRECTION OF COMPASS NEEDLES
IMAGINARY VERTICAL PLANE A-B-C-D WHICH BISECTS ANGLE α
D
C
METHOD OF DEFLECTING COMPASS BY PERMANENT MAGNET

Figure 6–33. Method of deflecting compass by permanent magnet.

6–126. COMPENSATION OF NE AND NW COMPONENTS

(1) *Intercardinal mounting.* For intercardinally mounted coils, the horizontal components which are compensated are the NE and the NW components.

(2) *Order of compensation.* The larger component should be compensated first.

(3) *Compensation of NE component.* The following procedure should be used for compensating the NE component.

(a) Replace the dip needle with the regular compass.

(b) Deflect the compass to a 45° or 225° reading by the procedure described in art. 6–124 (2).

(c) Energize one degaussing coil with its maximum current and note the compass deflection. If the compass does not deflect, steps (d) and (e) are not necessary for this degaussing coil.

(d) Increase or decrease current in the NE compensating coil winding for the degaussing coil being compensated to make the compass return to the heading obtained in step (2). This may require shorting out or adding fixed resistors as well as adjusting the variable resistor in the control box, and it may also require reversing the compass compensating coil leads. To see if the coil leads need reversing, note the compass deflection with and without the compensating coil in the circuit. Reverse the leads if the deviation with the coil in the circuit is in the same direction and larger than when the coil is not in the circuit.

(e) Check the current through the coil and the variable and fixed resistors in the control box to make sure that the current in each circuit element is no greater than the current rating of the element.

(f) Reduce the degaussing coil current to zero and then increase to a maximum in the other direction. Note any deviations and make any refinements necessary.

(g) Reduce the degaussing coil current to zero by reversals (see art. 6–129).

(h) Repeat operations (c) to (g), inclusive, for each degaussing coil.

(i) Record the compass compensation data as it is taken, on NAVSHIPS 2525 (see fig. 6–32).

(4) *Compensation of NW component.* The procedures given above for compensation of the NE component is repeated for compensation of the NW component except that the compass is deflected in step (b) to a reading of 45° or 225°.

6–127. CHECK ON RESISTOR SETTINGS

A major change of the current in one compass coil winding will change the voltage drop in the compass coil power supply leads, and will change the voltage applied to the other compass coil windings. Hence, when one or more compasses are being compensated, all coils of all the compasses should be approximately compensated before making the final resistor settings. If only one compass coil is installed aboard ship, the resistor settings may be made immediately after compensation because there are no other coils to be adjusted and no possibility of disturbing the adjustment of the single coil.

6–128. CHECK FOR RESIDUALS

With the compass deflected to a reading of about 90° or 270°, energize a degaussing coil with its maximum positive value, and then deenergize without reversals. If the compass fails to return to within one degree of its original reading, that particular degaussing coil should be secured by a series of reversals as explained in art. 6–129. Each degaussing coil should be checked for residuals for both positive and negative coil current. If a coil should require securing by reversals, this fact should be noted on form NAVSHIPS 2525 (fig. 6–32) by an entry under "Remarks" and on form NAVSHIPS 1104 (fig. 6–34) by inserting the designations of the coils which should be cycled, that is, secured by the method of reversals.

6–129. SECURING BY REVERSALS

The Adjuster should secure coils by reversal when specified in the procedure for compass compensation given above. The procedure for securing a degaussing coil by reversals is as follows:

(1) Starting with the maximum current specified in the Degaussing Folder, reduce the current to zero and then increase to the starting value in the reverse direction.

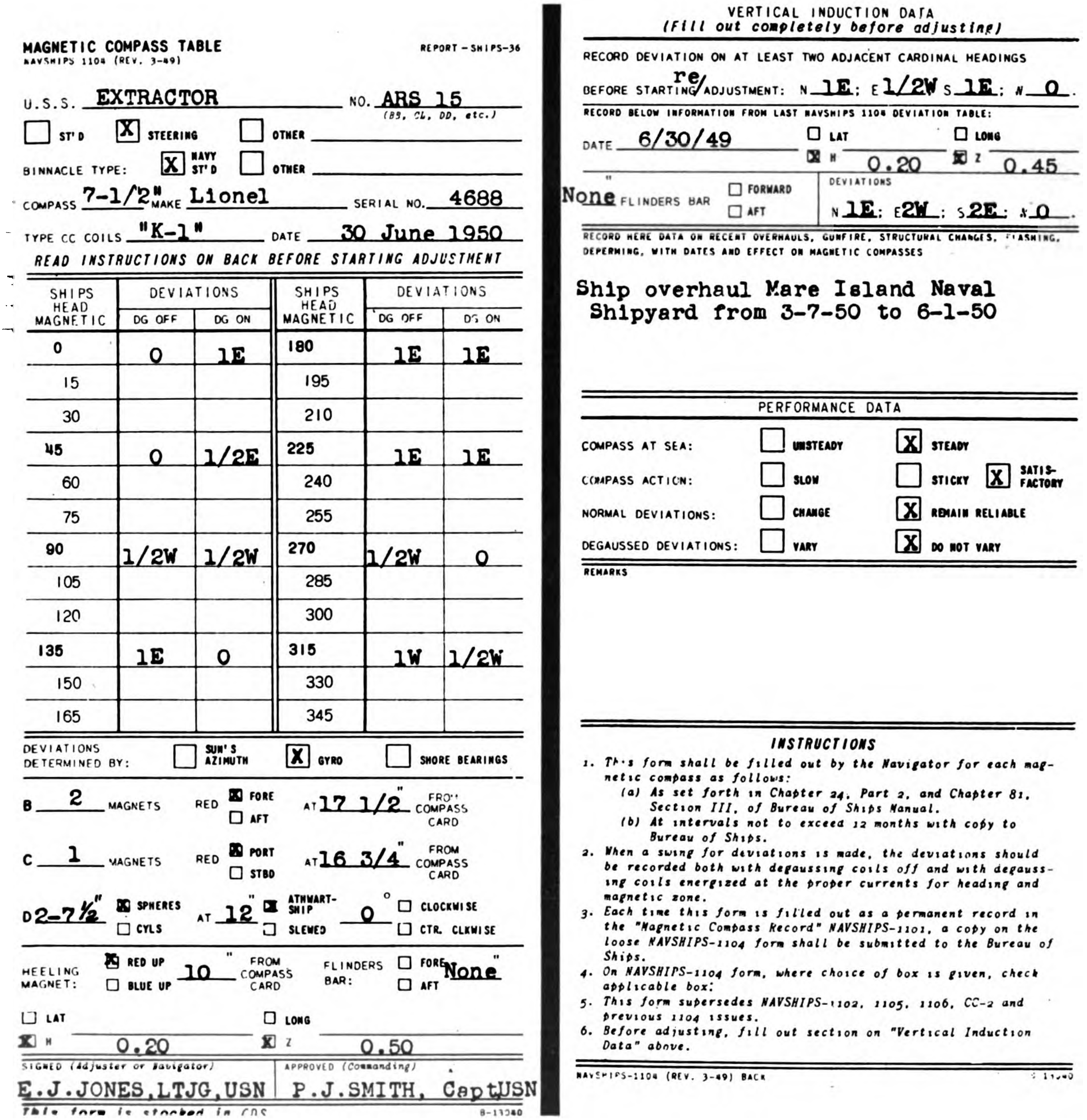
(2) Reduce the current to zero and then increase to ¾ value in the original direction.

(3) Reduce the current to zero and then increase to ½ value in the reverse direction.

(4) Reduce the current to zero and then increase to ¼ value in the original direction.

(5) Reduce the current to zero and then increase to ⅛ value in the reverse direction.

(6) Reduce the current to zero.



MAGNETIC COMPASS TABLE
NAVSHIPS 1104 (REV. 3-49)
REPORT – SHIPS-36

U.S.S. EXTRACTOR NO. ARS 15 (BB, CL, DD, etc.)

☐ ST'D ☒ STEERING ☐ OTHER

BINNACLE TYPE: ☒ NAVY ST'D ☐ OTHER

COMPASS 7-1/2" MAKE Lionel SERIAL NO. 4688

TYPE CC COILS "K-1" DATE 30 June 1950

READ INSTRUCTIONS ON BACK BEFORE STARTING ADJUSTMENT

SHIPS HEAD MAGNETIC	DEVIATIONS DG OFF	DEVIATIONS DG ON	SHIPS HEAD MAGNETIC	DEVIATIONS DG OFF	DEVIATIONS DG ON
0	0	1E	180	1E	1E
15			195		
30			210		
45	0	1/2E	225	1E	1E
60			240		
75			255		
90	1/2W	1/2W	270	1/2W	0
105			285		
120			300		
135	1E	0	315	1W	1/2W
150			330		
165			345		

DEVIATIONS DETERMINED BY: ☐ SUN'S AZIMUTH ☒ GYRO ☐ SHORE BEARINGS

B 2 MAGNETS RED ☒ FORE ☐ AFT AT 17 1/2" FROM COMPASS CARD

C 1 MAGNETS RED ☒ PORT ☐ STBD AT 16 3/4" FROM COMPASS CARD

D 2-7½" ☒ SPHERES ☐ CYLS AT 12" ☒ ATHWARTSHIP ☐ SLEWED 0° ☐ CLOCKWISE ☐ CTR. CLKWISE

HEELING MAGNET: ☒ RED UP ☐ BLUE UP 10" FROM COMPASS CARD FLINDERS BAR: ☐ FORE ☐ AFT None"

☐ LAT ☐ LONG

☒ H 0.20 ☒ Z 0.50

SIGNED (Adjuster or Navigator) E.J.JONES,LTJG,USN

APPROVED (Commanding) P.J.SMITH, CaptUSN

This form is stocked in CDS
8-11340

VERTICAL INDUCTION DATA
(Fill out completely before adjusting)

RECORD DEVIATION ON AT LEAST TWO ADJACENT CARDINAL HEADINGS

BEFORE STARTING re/ADJUSTMENT: N 1E; E 1/2W S 1E; W 0.

RECORD BELOW INFORMATION FROM LAST NAVSHIPS 1104 DEVIATION TABLE:

DATE 6/30/49 ☐ LAT ☐ LONG

☒ H 0.20 ☒ Z 0.45

None" FLINDERS BAR ☐ FORWARD ☐ AFT

DEVIATIONS N 1E; E 2W; S 2E; W 0.

RECORD HERE DATA ON RECENT OVERHAULS, GUNFIRE, STRUCTURAL CHANGES, FLASHING, DEPERMING, WITH DATES AND EFFECT ON MAGNETIC COMPASSES

Ship overhaul Mare Island Naval Shipyard from 3-7-50 to 6-1-50

PERFORMANCE DATA

COMPASS AT SEA: ☐ UNSTEADY ☒ STEADY

COMPASS ACTION: ☐ SLOW ☐ STICKY ☒ SATISFACTORY

NORMAL DEVIATIONS: ☐ CHANGE ☒ REMAIN RELIABLE

DEGAUSSED DEVIATIONS: ☐ VARY ☒ DO NOT VARY

REMARKS

INSTRUCTIONS

1. *This form shall be filled out by the Navigator for each magnetic compass as follows:*
   - *(a) As set forth in Chapter 24, Part 2, and Chapter 81, Section III, of Bureau of Ships Manual.*
   - *(b) At intervals not to exceed 12 months with copy to Bureau of Ships.*
2. *When a swing for deviations is made, the deviations should be recorded both with degaussing coils off and with degaussing coils energized at the proper currents for heading and magnetic zone.*
3. *Each time this form is filled out as a permanent record in the "Magnetic Compass Record" NAVSHIPS-1101, a copy on the loose NAVSHIPS-1104 form shall be submitted to the Bureau of Ships.*
4. *On NAVSHIPS-1104 form, where choice of box is given, check applicable box:*
5. *This form supersedes NAVSHIPS-1102, 1105, 1106, CC-2 and previous 1104 issues.*
6. *Before adjusting, fill out section on "Vertical Induction Data" above.*

NAVSHIPS-1104 (REV. 3-49) BACK
11340

Figure 6–34. NAVSHIPS 1104 form.

Part 3—FINAL COMPENSATION

6–141. GENERAL

The final compensation is intended to be a refinement of the dockside compensation under actual operating conditions away from dockside magnetic disturbances and *after* a fairly accurate normal compass adjustment.

6–142. PROCEDURE

(1) *Compensation of H component.* The H component should be compensated first. The procedure is identical to that used for the dockside compensation (see art. 6–123).

(2) *Compensation of horizontal components.* In the final compensation, the compass is not deflected by a magnet as in the dockside compensation, but the *vessel* itself is placed on the heading which gives the compass reading desired for compensation. With this exception, the final compensation of the horizontal components is carried out in the same way as in the dockside compensation, art. 6–125 for cardinally mounted coils and art. 6–126 for intercardinally mounted coils.

6–143. ACCURACY OF COMPENSATION

(1) *Limits expected.* The compass compensating coils should reduce the compass deviations caused by the degaussing coil to as small a value as practicable. It is expected that under normal conditions the compass coils will compensate the vertical component of magnetic field produced by the degaussing coils to 10 milligauss or less, and will reduce the compass deviations produced by the degaussing coils to 2 degrees or less, *on any heading.* In some cases where the deviations produced by the degaussing coils are large (30° to 60°) before compensation, it may not be practicable to reduce the compass deviations to the 2 degree value. In such cases, it is expected that the deviations can always be reduced to less than 10 percent of the original deviation and normally can be reduced to less than about 7 percent of the original deviation.

(2) *Unsymmetrical deviations.* Unsymmetrical magnetic fields due either to the compass magnets or to the compass coils may, under unusual conditions, cause deviations which cannot be reduced to the limits given in art. 6–133 (1). Unsymmetrical deviations occur on different headings than those used for setting compass compensating coil currents. For cardinally mounted compass compensating coils the unsymmetrical deviations are maximum for headings other than N/S or E/W; for intercardinally mounted coils are maximum for headings other than NE/SW or NW/SE. Resetting the compass coil currents is not the answer to unsymmetrical deviations since the essence of the difficulty is that the compass compensating coil currents which make compass deviations small on cardinal or intercardinal headings, as the case may be, are not the right current values to make the deviations small on the intermediate headings where the unsymmetrical deviations are large. Similarly, the coil currents which would make the unsymmetrical deviations small would not be the right currents for cardinal or intercardinal headings.

(3) *Remedies for unsymmetrical deviations.* When unsymmetrical deviations are present, they can be brought to within the limits given in art. 6–133 (1) by the appropriate procedure indicated below:

(a) If the compass coils are of an early type, replace the compass coils with a modern assembly of known symmetry.

(b) Replace the magnetic compass with one of known symmetry.

(c) Relocate the binnacle at a position farther from degaussing coil crossovers, if this is agreeable to the Commanding Officer, or, alternatively:

(d) Relocate the degaussing coil crossover at a position farther from the binnacle if the new location will maintain an equally satisfactory magnetic signature. A check on whether the binnacle is too close to a degaussing coil crossover is given by the formula:

$$D=\frac{NI}{200}$$

where D=distance in feet
NI=total ampere turns of the degaussing coil at the crossover.

If the separation between the compass and the crossover is less than the distance given by the formula, a recommendation for relocation of the binnacle or crossover should be forwarded to the Bureau along with pertinent data on compass and crossover locations and the compass deviations when degaussing coils are energized (see art. 6–152).

Part 4—RECORDS OF COMPENSATION AND DEVIATION

6–151. NAVSHIPS 2525 FORM

(1) *When to fill out.* This form should be filled out at the time of the dockside compensation. The original should be kept in the Degaussing Folder on the ship, one copy should be kept in the District Degaussing records, and one copy should be forwarded to the Bureau of Ships.

(2) *How to fill out.* (a) Spaces are provided on the NAVSHIPS 2525 form for the inclusion of pertinent data regarding the compass, compass compensating coils, control boxes, etc., together with a space for "Remarks" which should include special features or difficulties such as type "A" heeling coils or hysteresis effects which make it necessary to

secure degaussing coils by reversals. If types "K," "K-1," and "K-2," "Filled K" or "T" coils are installed, the NAVSHIPS 2525 form in the instruction manual for the coil should be filled out. These forms remain in the manuals as part of the record of the compass compensating system. These manuals and records should be placed in the vessel's Degaussing Folder.

(b) Figure 6-32 illustrates the usual method of filling in NAVSHIPS 2525. Under item 4, it would be helpful to subsequent adjusters, as well as to the Bureau where the records are frequently referred to for degaussing effect data and compass coil history, if such comments as "accurate," "rough", or "normal adjustment not yet accomplished" are added above or below the appropriate column. In this manner, correct coil, compass, and ship data may be noted without placing too much dependence on degaussing effects where the compass directive force is incorrect as a result of incorrect Flinders bar or magnet placement or hurried positioning of the deflector magnet. The "H Effect" under item 4 is a measure of the vertical component of magnetic field produced at the compass by the degaussing coils, and the vertical component is usually larger than the horizontal components. To obtain information on its magnitude, it is desirable to use a magnetometer or a calibrated dip needle to measure the H component in milligauss for the first few ships of a class. Thereafter, qualitative notes such as "none," "slight," "medium," or "great" are usually satisfactory. Under item 5, it is desirable to fill in complete information, when possible, particularly for the first ships of a class and for the first installations of a new type of compass coil.

(3) *Final compensation.* It is not necessary to make out a NAVSHIPS 2525 form for the final compensation at sea unless trouble occurs or radical changes from the data recorded in the dockside form are noted as a result of last minute degaussing coil or structural changes or electrical faults.

6-152. NAVSHIPS 1104 FORM

In order to provide the ship with a record of compensated degaussing deviations for navigational purposes, the ship should be swung after the final compensation with the degaussing coil currents set at the correct zone values for each heading as specified in the ship's Degaussing Folder. The compensated deviations with degaussing on should be taken, preferably immediately after normal deviations with degaussing off are obtained, and recorded on form NAVSHIPS 1104. Fig. 6-34 shows an example of this form.

Section 6—SOURCES OF INFORMATION

6-161. LIST OF REFERENCES

Further information on compass compensating coils and compass compensation is to be found in:

(1) Manuals.

Type "K" Coils—"Installation Data" NAVSHIPS (660g) S81-6 dated 10 November 1943.

Type "K" Coils—"Maintenance and Compensation Data" NAVSHIPS (660g) S81-6 dated 1 May 1944.

Type "K-1" Coils—"Installation Data" NAVSHIPS (660g) S81-6 dated 1 February 1945.

Type "K-1" Coils—"Maintenance and Compensation Data" NAVSHIPS (660g) S81-6 dated 15 February 1945.

Type "T" Coils—"Installation and Compensation Data" NAVSHIPS (660g) S81-6. dated 1 July 1944.

General information—"Adjustment and Compensation" H. O. No. 226 dated April 1944.

(2) Drawings.

Type "A" Control box, six-lug—Construction Details; Bu #S8106—672387, Jaye and Nieberg #504 Alt. 2.

Type "A" Terminal box—Construction Details; Bu #10-T-2166-L.

Type "A" Branch box—Construction Details; Bu #10-T-2171-L-2.

Type "G" Adapter Bracket—Bu #S8106-737955-6 and -7.

Type "K" Coil—Assembly and Dimensions—Bu #S8106-435094, Alt. 0 Sheet 43.

Type "K-1" Coil—Assembly and Dimensions—Bu #S8106-655855; Anaconda Wire and Cable Co. #AS13295.

Type "T" Coil—Assembly and Dimensions—Bu #S8106-544487; Jaye and Nieberg #563.

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Chapter 7

SUPPLY OF DEGAUSSING MATERIAL

7-1. STOCKS OF DEGAUSSING MATERIAL

When degaussing materials incorporating new designs or developments are to be stocked, the Bureau of Ships procures the initial quantities, places them in the appropriate supply system and recommends the minimum stock levels to be maintained. These stock levels are then maintained by purchases made by the appropriate supply demand control point.

7-2. CLASSES OF DEGAUSSING MATERIAL

Because of the differences in the nature of the materials used for degaussing systems and in the methods of accounting for these materials, different methods are used for the control of several broad classes of degaussing materials. All degaussing materials are divided into the following classes:

(a) BuShips Special Material.
(b) BuShips Repair Parts.
(c) General Stores Material.
(d) Items furnished by the installing yard.

7-3. BUREAU OF SHIPS SPECIAL MATERIAL

The class of material known as "Bureau of Ships Special Material" is defined to be machinery or equipment which is under the cognizance of the Bureau of Ships and which, because of its design or specified use, is intended primarily for shipboard use, normally an item of permanent shipboard equipment (non-consumable). The items of degaussing equipment which fall in this class can be obtained from the Bureau of Ships.

7-4. BUREAU OF SHIPS REPAIR PARTS

(1) The class of material known as "Bureau of Ships Repair Parts" consists of parts, fittings, or accessories of equipment which is Bureau of Ships Special Material, and complete equipments on which standardized BuShips designs have been established. These items are stocked in the Ships Parts Supply System and are under the procurement and inventory control of the Ships Parts Control Center, Naval Supply Depot, Mechanicsburg, Pennsylvania.

(2) Degaussing items in this class can be obtained through the Ships Parts Supply System.

7-5. GENERAL STORES MATERIAL

(1) The class of material known as "General Stores Material" consists of standard items of equipment which are usually of such a nature as to be suitable for use in a number of different fields, of which degaussing is only one. General Stores Material is stocked in the General Supply System.

(2) Degaussing items in this class can be obtained through the General Supply System.

7-6. MATERIAL FURNISHED BY THE INSTALLING YARD

This class includes all items and appurtenances needed to complete the degaussing system except the special major items of equipment found in one of the other three classes. Switchboards and remote panels are examples of components which are sometimes furnished by the installing yard, sometimes by the Bureau of Ships. When furnished by the installing yard, they are usually fabricated by the yard or procured locally, and are tailor-made to fit a particular installation. This makes stocking impractical.

7-7. OBTAINING MATERIAL

(1) *New installations and alterations.* On new installations, conversions, and approved alterations, the Bureau of Ships installation instruction letter will specify which material is to be government furnished and which is to be furnished by the installing yard. This letter will also specify which items of the government furnished material will be shipped directly to the yard by the Bureau of Ships and which items are to be obtained by the Supervisor of Shipbuilding or Naval Shipyard through the appropriate supply system. The items to be obtained by the Supervisor of Shipbuilding or the Naval Shipyard should be requisitioned in accordance with NAVSHIPS 250-4060, BUSHIPS MATERIAL REQUISITIONING GUIDE. This publication gives the proper supply system for all the types of material which may be government furnished.

(2) *Repairs.* On installations requiring repairs at Naval Shipyards, the yards should requisition the needed Bureau of Ships Material, Bureau of Ships Repair Parts, and General Stores Material directly through the supply systems. All other material needed to complete the job should be locally procured or fabricated by the yard. On installations being repaired at private shipyards the same procurement procedure applies. The naval activity in charge of having the repair accomplished should do the requisitioning while the private yard procures or fabricates those items not normally supplied by the government.

(3) *Stocking by naval activities.* It is recommended that within the limits allowed by existing general stocking directives, naval repair activities

carry at least a minimum stock level of each of those items of degaussing equipment found to be necessary by them to accomplish urgent degaussing repairs without causing delay to ships assigned short availabilities. This includes such commonly used items as degaussing cable, rheostats, resistors, ammeters, reversing and disconnect switches, indicator light assemblies and lamps, stuffing tubes, terminal strips, compass compensating coils, and control boxes and control box resistor assemblies.

Chapter 8

TESTING AND REPORTING OF NEW INSTALLATIONS

Section 1. TESTING

8-1. REASON FOR TESTS

After a degaussing installation has been completed, it should be tested to make sure that it conforms to specifications, both electrically and mechanically.

(1) *Naval vessels.* The specifications and design to which the degaussing installation on a naval vessel must conform are:

(a) Section S81-6 of General Specifications for Machinery for Vessels of the United States Navy, and other sections of the General Specifications which are referenced in section S81-6.

(b) The Bureau of Ships installation letter on the specific ship (or class), to the design or installing yard via the Superintendent of Shipbuilding, or the Commander of a Naval Shipyard, and the degaussing plans prepared on the basis of this letter.

(2) *Merchant vessels.* The specifications and design to which the degaussing installation on a merchant vessel must conform are the installation letter on the specific ship (or class) and the degaussing plans prepared on the basis of this letter.

8-2. OPERATING TEST FOR NAVAL VESSELS

Section S81-6 of General Specifications requires that each degaussing coil and its associated control equipment shall be subjected to a ten-hour operating test as follows, prior to the trial trips of the vessel:

(1) 2 hours with positive current and at one-half the specified ampere turn capacity of the degaussing coil.

(2) 2 hours with negative current and at one-half the specified ampere turn capacity of the degaussing coil.

(3) 3 hours with positive current and at full specified ampere turn capacity for the degaussing coil.

(4) 3 hours with negative current and at full specified ampere turn capacity for the degaussing coil.

8-3. OBSERVATIONS DURING TEN-HOUR TEST FOR NAVAL VESSELS

The following checks and tests during the ten-hour test are required by Section S81-6 of General Specifications:

(1) *Temperature rise.* (a) During the 10-hour test, readings of degaussing coil current and voltage shall be made, and the average temperature rise of the degaussing coil shall be calculated by the formula:

$$\text{Temperature rise °C.} = (234.5+T_c)\frac{R_h}{R_c} - (234.5+T_a)$$

when R_c=cold resistance of degaussing coil.

R_h=hot resistance of degaussing coil.

T_c=temperature of (°C.) of degaussing coil when cold resistance was measured.

T_a=ambient temperature (°C.) during the last quarter of the test.

(b) Other temperature checks, as considered desirable by the Navy Inspector, shall be made on cables which are installed where ventilation is poor, where the cables may be heated by other sources, or where the cables are grouped. The insulation resistance shall be measured at the conclusion of the 10-hour test. (See art. 8-5 (5).)

(2) *Coil capacity.* Each coil shall be subjected to tests at various loads from zero to full specified ampere turn capacity in both positive and negative direction to check the following:

(a) Suitability of control for changing the degaussing coil currents.

(b) Maximum change of current per rheostat step.

(c) Stability of degaussing coil currents on all loads.

(d) Polarity of degaussing coils.

(3) *Other observations.* During the tests outlined in arts. 8-2 and 8-3 (2), careful observation shall be made of noise, balance, lubrication, and commutation of the special degaussing motor-generator sets (if used) under all conditions.

8-4. TESTS ON MERCHANT VESSEL INSTALLATIONS

The tests on merchant vessels should be the same as described in arts. 8-2 and 8-3 for Naval vessels.

8-5. ADJUSTMENTS AND OBSERVATIONS—ADDITIONAL INFORMATION

(1) *Adjustment of series resistors.* If this adjustment has not been made before, the series resistors should be adjusted when the coil is up to operating temperature. With all rheostat resistance

out of the circuit, the series resistor should be adjusted so that the current is not greater than can be carried safely by the circuit element having the lowest current-carrying capacity. In the case of multicircuit rheostats, the series resistor in each of the individual coil circuits should be adjusted to limit the current in each circuit to a safe value. On motor-generator installations, additional resistance should be installed in series with the degaussing generator field, if necessary, to limit the current to a safe value and to permit the entire field rheostat resistance to be used for control purposes.

(2) *Ventilation.* (a) The ventilation of the motor-generator room should be sufficient to dissipate the heat developed when the degaussing generator is delivering maximum required coil current.

(b) For coils in which the current is controlled by a rheostat and series resistors, the maximum amount of heat will be developed in the rheostat and series resistor combination when the voltage drop across it is one-half the line voltage. Ventilation should be checked for this condition to make sure that it is adequate to carry off the heat developed.

(3) *Electrical connections.* Conductor connections should be checked in all connection and through boxes for looseness, undue temperature rise, and sufficiency of insulation.

(4) *Heading control switches.* Heading control switches for FI–QI and A coils should be operated to break positive coil current about 10 times while the coil is carrying maximum current. The time interval between successive current interruptions should be about 10 seconds. Switch contacts should not show any appreciable deterioration after this test.

(5) *Insulation resistance.* The insulation resistance to ground for each coil should be measured both at the start and finish of the operating test. Usually the insulation resistance will decrease as cable temperature increases. This is a normal characteristic of the kind of cable insulation used. The insulation resistance of a degaussing coil in a new installation should be in excess of 0.2 megohm. If it is not, measure the cable insulation resistance per foot in accordance with the instructions given in Section S62–3 of General Specifications for Machinery for Vessels of the United States Navy and in chapter 60 of the Bureau of Ships Manual. If the measured insulation resistance per foot is above the minimum insulation resistance for degaussing cable given by fig. 8–1 (taken from Section S62–3 of General Specifications) the cable insulation resistance can be considered satisfactory. Note that the minimum insulation resistance per foot given by fig. 8–1 is considerably higher than the value given by fig. 9–3 in chapter 9. This is because fig. 8–1 gives minimum insulation resistance per foot for new installations, fig. 9–3 for installations which are in use and for which lower values are acceptable than in new installations.

Section 2. REPORTING

8–11. REPORTS REQUIRED

(1) The following report forms, which should be filled in by the Industrial Degaussing Group for the district in which the installation is made, are required for all vessels to which the report applies (for example, DGP 31 and DGP 32, see art. 8–12, would not be required for vessels which have only an M coil installation):

TABLE 8–1.—*Number of copies to*

Report	BuShips	BuOrd	Vessel
DGP 30	1	1	1
DGP 31	1	1	1
DGP 32	1	1	1
DGP 33a	1	1	1
NAVSHIPS 2525	1	0	1
NBS 1104	1	0	1

(2) One copy of each DGP form for merchant vessels should also be forwarded to the Maritime Administration, Maintenance and Repair Division, New York City, for operating merchant vessels or to the Maritime Administration, Washington, D. C., for new construction merchant vessels.

8–12. DGP FORMS

The DGP forms can be obtained from the Bureau of Ordnance. The DGP forms will be the only Bureau records of the completion of a degaussing installation. It is essential that the form or forms, as necessary, be completed and be forwarded as soon as possible after the installation has been completed. These forms should be completed for all vessels, United States or foreign, degaussed under United States cognizance. The DGP forms and their use are as follows:

(1) Forms DGP 30, 31, 32 and 33a, as applicable, are to be used for reporting completed degaussing installations.

(a) DGP 30 is the INSTALLATION CERTIFICATE FOR THE M COIL.

(b) DGP 31 is the INSTALLATION CERTIFICATE FOR THE FI–QI AND FP–QP COILS.

(c) DGP 32 is the INSTALLATION CERTIFICATE FOR THE A COIL.

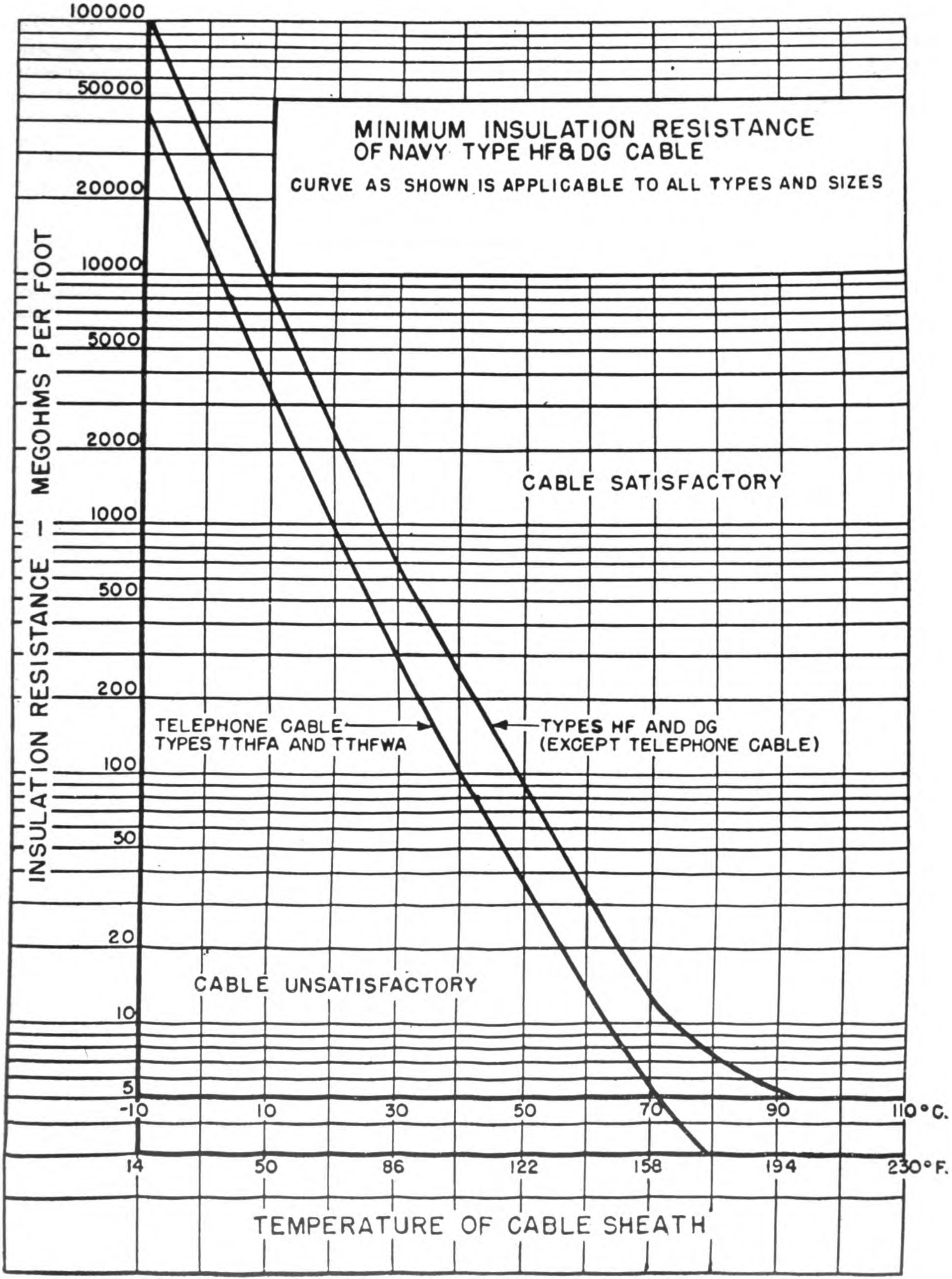

Figure 8–1. Cable insulation resistance as a function of temperature. Minimum values for new installation.

(d) DGP 33a is the INSTALLATION CERTIFICATE FOR THE MALMAUX SYSTEM ON MINESWEEPERS.

(e) DGP 39, which is not used for new installations, is the CERTIFICATE OF MODIFICATION OF THE DEGAUSSING INSTALLATION. Form DGP 39 is to be issued when there is any change or modification of the degaussing installation from the condition described in the installation certificates contained in the DEGAUSSING FOLDER for the vessel. While not for use on new installations, this form may be used by the degaussing inspector to report additions or modification to an installation at a repair yard. When used, copies of form DGP 39 should be submitted in the same quantities listed for DGP 30.

8–13. NAVSHIPS 2525

The installation and initial adjustment of compass compensating coils should be reported on NAVSHIPS 2525 form. This form can be obtained from the Bureau of Ships. A separate copy of this form should be used for each compass compensated. Subsequent adjustments of the compass coils need not be reported unless trouble is encountered and major changes are made.

8–14. NAVSHIPS 1104

This form can be obtained from the Bureau of Ships. It should be used for reporting the data obtained when a ship is swung for compass deviations.

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Chapter 9

INSPECTION OF OPERATING INSTALLATIONS

Section 1. GENERAL INFORMATION ON INSPECTION

9–1. PURPOSE OF ROUTINE INSPECTION

Routine inspections of the degaussing installations on operating naval and merchant vessels should be made periodically to ensure that the installations are in satisfactory condition. These routine inspections are subsequent to the initial tests and inspections made at the completion of the installations. The inspection of new installations should be made in accordance with Chapter 8 by the Industrial Degaussing Group having cognizance over installation work at the yard where the installation work is done. The routine inspections which come later when the vessel is operating and which are covered in this chapter are to be made by the Industrial Degaussing Group.

9–2. WHEN TO INSPECT

(1) An inspection should be made whenever a vessel becomes available at a port where an Industrial Degaussing Group is maintained, if more than thirty days have elapsed since the last previous inspection for minesweepers, or ninety days for all other vessels. An inspection need not be made if the last previous inspection was within thirty or ninety days, as applicable, unless an inspection is requested by the Commanding Officer of the vessel, either naval or merchant; or unless the Watch List or other information available to the Industrial Degaussing Group indicates that an inspection should be made; or unless the last previous inspection was airly close to thirty or ninety days before and the uture operating schedule of the vessel is such as o suggest that a considerable period of time will lapse before there will be another opportunity for n inspection. In all such cases, an inspection hould be made.

(2) An inspection should be made as soon as pos-ble after the arrival of a vessel to allow maximum me for making any repairs that may be necessary. egaussing repairs should be made during the ves-el's availability to put the degaussing installation n satisfactory operating condition, replacing cable nd other degaussing equipment where necessary.

(3) In some cases it may be desirable to expedite he inspection by boarding a vessel while it is proceeding to a berth. Inspection of vessels on which ouble is known to exist should be given prefer-nce. The thoroughness of the inspection will depend upon the length of the vessel's availability, the work load at the degaussing activity, and the condition of the degaussing installation.

9–3. ADVANCE INFORMATION

If possible, arrangements should be made to provide the inspectors with advance information on time of arrival of a vessel and condition of the degaussing installation. If there is a range over which the vessel passes before coming into port, range personnel should inform the inspectors that the vessel is coming and also whether or not any irregularities were noted when the vessel passed over the range. Coast Guard ship arrival lists may also give useful information on the arrival of vessels. Any conditions known by the Bureau of Ships or the Bureau of Ordnance to require attention are reported on the Bureau of Ordnance "Watch List". The "Watch List" should, therefore, always be checked for items that require attention.

9–4. APPROVAL OF COMMANDING OFFICER

All inspections, changes, and/or repairs of the degaussing installation should be made with the knowledge of and subject to the approval of the Commanding Officer or Master of the vessel.

9–5. REPORTING INSPECTIONS TO THE BUREAU OF SHIPS

Two types of inspection information are desired by the Bureau of Ships.

(1) The first type is information on repairs required on a particular vessel, the extent of the repairs, and the cause of the repairs. This type of information is to be reported on Bureau of Ships Degaussing Repair Report Form NAVSHIPS 2944. See art. 9–6.

(2) The second type is information on the total number of inspections made during a month and the general satisfactoriness of the installations inspected. This report is to be made once a month on Bureau of Ships Summary Degaussing Report Form NAVSHIPS 2944A. See art. 9–7.

9–6. NAVSHIPS 2944

(1) *Information to be reported.* A NAVSHIPS 2944 form should be completed for each vessel requiring repairs unless the repairs are minor items such as replacement of indicator lights, adjustment of series resistors, and so on. Replacement of cable, rheostats, ammeters, switches, etc., and faulty operation of equipment should be reported. In the case

of cable replacement, the report should give the location and type of defective cable and the amount of replacement cable required. In general, repairs to all items which are listed on the NAVSHIPS 2944 form should be reported. Replacement or repair of compass compensating coil equipment should be reported on NAVSHIPS 2944, but routine recompensations of the compass coils need not be reported on NAVSHIPS 2944 unless the recompensation was necessitated by failure of the compass coils or control circuits. Completed NAVSHIPS 2944 form is shown in fig. 9–1a and fig. 9–1b.

(2) *Disposition of copies.* The NAVSHIPS 2944 form should be filled out in duplicate. One copy is for the Bureau of Ships and one is to be retained for local use and information. No copy is needed for the vessel. The accumulated copies for the Bureau of Ships should be forwarded at least once every month, marked for the attention of Code 560 M. No forwarding letter is required.

9–7. NAVSHIPS 2944A

A NAVSHIPS 2944A form should be completed each month by each activity engaged in degaussing inspection work and forwarded to the Bureau of Ships, attention Code 560 M. No forwarding letter is required. The report should state whether it covers an entire Naval District or not. If it does not cover an entire district, the report should clearly show what locality is covered by the report and also what other activities will be forwarding separate reports. See fig. 9–2 for a completed form.

9–8. RECOMMENDATIONS FOR WATCH LIST ACTION

Requests for Watch List action on degaussing coil and compass repair action can be made to the Bureau of Ships in NAVSHIPS 2944. In this case it should be made clear that Watch List action is requested, and also whether or not a recommendation for such action has been submitted separately to the Bureau of Ordnance. When urgent action items are discovered that cannot be repaired during the course of an overhaul which is being made, form DPG 40X should be filled out with one copy each to the Bureau of Ordnance, the Bureau of Ships, and the vessel.

Section 2—INSPECTION AND TESTS

9–21. EQUIPMENT

The following equipment, or its equivalent, will be useful in making an inspection.

(1) *Polarity indicator.* This is essentially the same as a small compass. When held near a coil, the motion of the magnetic needle will indicate the direction of current. See art. 2–2 of this manual for polarity checks on degaussing coils.

(2) *Tong-test ampere turn meter.* This instrument reads ampere turns directly. A split magnetic loop of the meter clamps over the cable so that connections need not be opened to take readings.

(3) *Volt-ohm-milliammeter test set.* This set is used for testing circuits, finding reversed or short circuited turns, checking voltages and currents in compass compensating coil circuits, etc. It should not be used as a standard instrument.

(4) *Insulation resistance measuring instrument.* These instruments are hand cranked or battery operated and are used for measuring the insulation resistance of circuits and machines.

(5) *Standard ammeter.* This meter is used to check and calibrate degaussing installation ammeters.

(6) *Voltage indicators.* These instruments are used to indicate energized circuits.

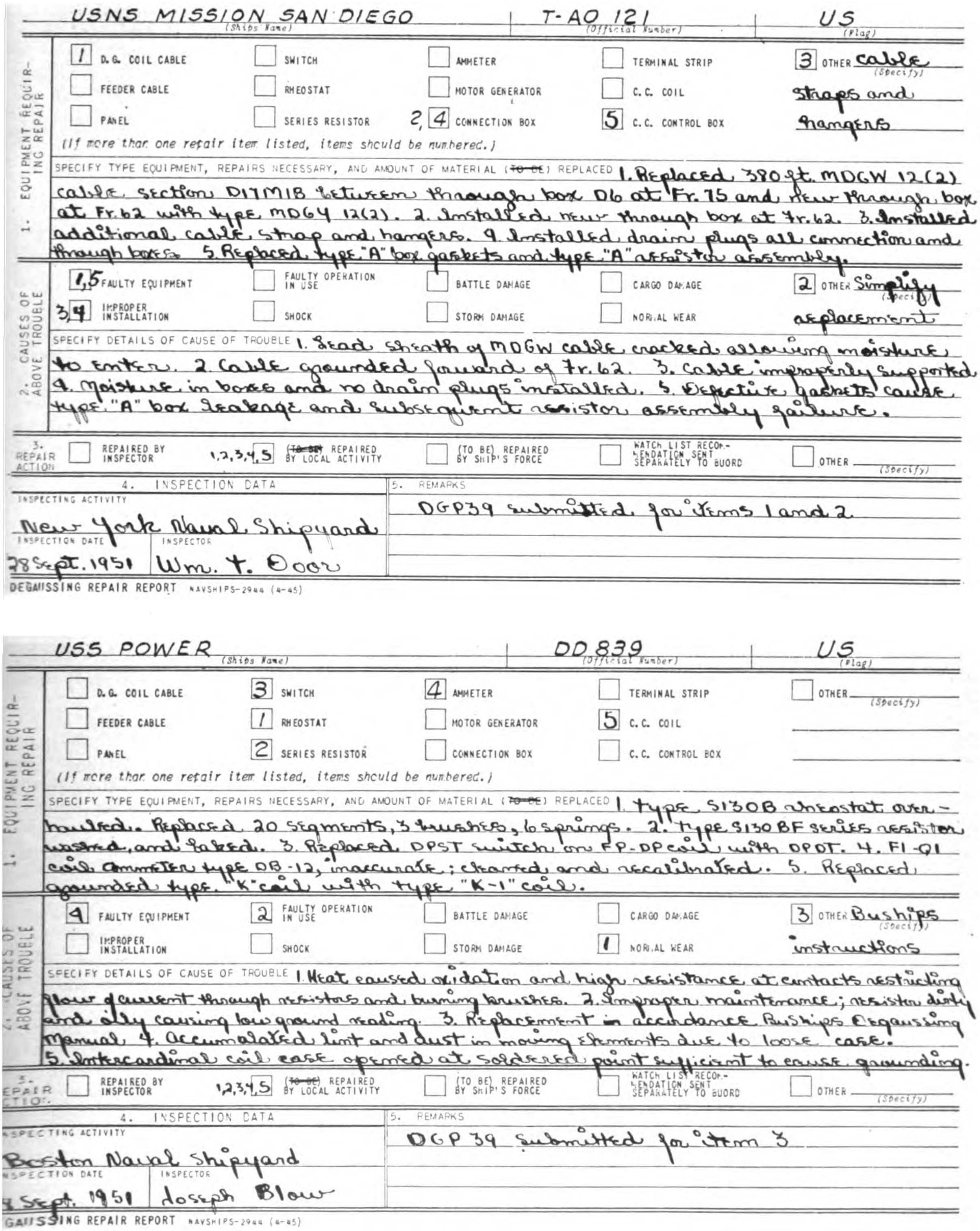
9–22. PRELIMINARY ACTION

(1) Upon boarding a vessel, the degaussing inspector should contact the Master, Commanding Officer, Engineer Officer, Officer of the Deck, or First Mate and obtain his comments on the operation and condition of the degaussing installation. Anything that might indicate a failure or a probable failure of the system should be considered, such as cables grounded, fuses blown, cables damaged, unsatisfactory operation of equipment, etc. If any items concerning the vessel are on the Watch List, it may be desirable to discuss them with the cognizant ship's personnel at this time.

(2) Available information on the degaussing installation should be reviewed. The ship's Degaussing Folder should contain most of the pertinent information including data on the original installation and modifications, calibration range recommendations, and the last inspection report which will inform the degaussing inspector of the condition of the installation where the last inspection was made. The Degaussing Folder should be inspected to see whether or not it has been revised to the latest form. If any of the DCP 30 series forms are missing, it may be possible to furnish them. Plans and specifications may be useful if they are available on the vessel, particularly if connections are to be changed or trouble is to be located.

(3) The Navigating Officer should be contacted to obtain his comments on the operation of the compass compensating coils. Differences in deviations when the degaussing coils are on an off, effect of heeling on the compass, etc., are points to be considered.

(4) The ship's Engineer Officer, or whoever is primarily responsible for operation of the degaussing installation, should be contacted for his comments. If possible, he should accompany the degaussing inspector during the inspection. The abil-



USNS MISSION SAN DIEGO (Ships Name) | T-AO 121 (Official Number) | US (Flag)

1. EQUIPMENT REQUIRING REPAIR

1 D.G. COIL CABLE	☐ SWITCH	☐ AMMETER	☐ TERMINAL STRIP	3 OTHER cable straps and hangers (Specify)
☐ FEEDER CABLE	☐ RHEOSTAT	☐ MOTOR GENERATOR	☐ C.C. COIL	
☐ PANEL	☐ SERIES RESISTOR	2, 4 CONNECTION BOX	5 C.C. CONTROL BOX	

(If more than one repair item listed, items should be numbered.)

SPECIFY TYPE EQUIPMENT, REPAIRS NECESSARY, AND AMOUNT OF MATERIAL (~~TO BE~~) REPLACED 1. Replaced 380 ft. MDGW 12(2) cable section D17M1B between through box D6 at Fr. 75 and new through box at Fr. 62 with type MDGY 12(2). 2. Installed new through box at Fr. 62. 3. Installed additional cable, strap and hangers. 4. Installed drain plugs all connection and through boxes. 5. Replaced type "A" box gaskets and type "A" resistor assembly.

2. CAUSES OF ABOVE TROUBLE

1,5 FAULTY EQUIPMENT	☐ FAULTY OPERATION IN USE	☐ BATTLE DAMAGE	☐ CARGO DAMAGE	2 OTHER Simplify replacement (Specify)
3, 4 IMPROPER INSTALLATION	☐ SHOCK	☐ STORM DAMAGE	☐ NORMAL WEAR	

SPECIFY DETAILS OF CAUSE OF TROUBLE 1. Lead sheath of MDGW cable cracked allowing moisture to enter. 2. Cable grounded forward of Fr. 62. 3. Cable improperly supported 4. Moisture in boxes and no drain plugs installed. 5. Defective gaskets cause type "A" box leakage and subsequent resistor assembly failure.

3. REPAIR ACTION

☐ REPAIRED BY INSPECTOR	1,2,3,4,5 (~~TO BE~~) REPAIRED BY LOCAL ACTIVITY	☐ (TO BE) REPAIRED BY SHIP'S FORCE	☐ WATCH LIST RECOMMENDATION SENT SEPARATELY TO BUORD	☐ OTHER (Specify)

4. INSPECTION DATA

INSPECTING ACTIVITY New York Naval Shipyard

INSPECTION DATE 28 Sept. 1951

INSPECTOR Wm. T. Door

5. REMARKS DGP39 submitted for items 1 and 2.

DEGAUSSING REPAIR REPORT NAVSHIPS-2944 (4-45)

USS POWER (Ships Name) | DD 839 (Official Number) | US (Flag)

1. EQUIPMENT REQUIRING REPAIR

☐ D.G. COIL CABLE	3 SWITCH	4 AMMETER	☐ TERMINAL STRIP	☐ OTHER (Specify)
☐ FEEDER CABLE	1 RHEOSTAT	☐ MOTOR GENERATOR	5 C.C. COIL	
☐ PANEL	2 SERIES RESISTOR	☐ CONNECTION BOX	☐ C.C. CONTROL BOX	

(If more than one repair item listed, items should be numbered.)

SPECIFY TYPE EQUIPMENT, REPAIRS NECESSARY, AND AMOUNT OF MATERIAL (~~TO BE~~) REPLACED 1. Type S130B rheostat overhauled. Replaced 20 segments, 3 brushes, 6 springs. 2. Type S130BF series resistor washed and baked. 3. Replaced DPST switch on FP-DP coil with DPDT. 4. FI-QI coil ammeter type DB-12, inaccurate; cleaned and recalibrated. 5. Replaced grounded type "K" coil with type "K-1" coil.

2. CAUSES OF ABOVE TROUBLE

4 FAULTY EQUIPMENT	2 FAULTY OPERATION IN USE	☐ BATTLE DAMAGE	☐ CARGO DAMAGE	3 OTHER Buships instructions (Specify)
☐ IMPROPER INSTALLATION	☐ SHOCK	☐ STORM DAMAGE	1 NORMAL WEAR	

SPECIFY DETAILS OF CAUSE OF TROUBLE 1. Heat caused oxidation and high resistance at contacts restricting flow of current through resistors and burning brushes. 2. Improper maintenance; resistor dirty and oily causing low ground reading. 3. Replacement in accordance Buships Degaussing Manual. 4. Accumulated lint and dust in moving elements due to loose case. 5. Intercardinal coil case opened at soldered point sufficient to cause grounding.

3. EPAIR CTION

☐ REPAIRED BY INSPECTOR	1,2,3,4,5 (~~TO BE~~) REPAIRED BY LOCAL ACTIVITY	☐ (TO BE) REPAIRED BY SHIP'S FORCE	☐ WATCH LIST RECOMMENDATION SENT SEPARATELY TO BUORD	☐ OTHER (Specify)

4. INSPECTION DATA

SPECTING ACTIVITY Boston Naval Shipyard

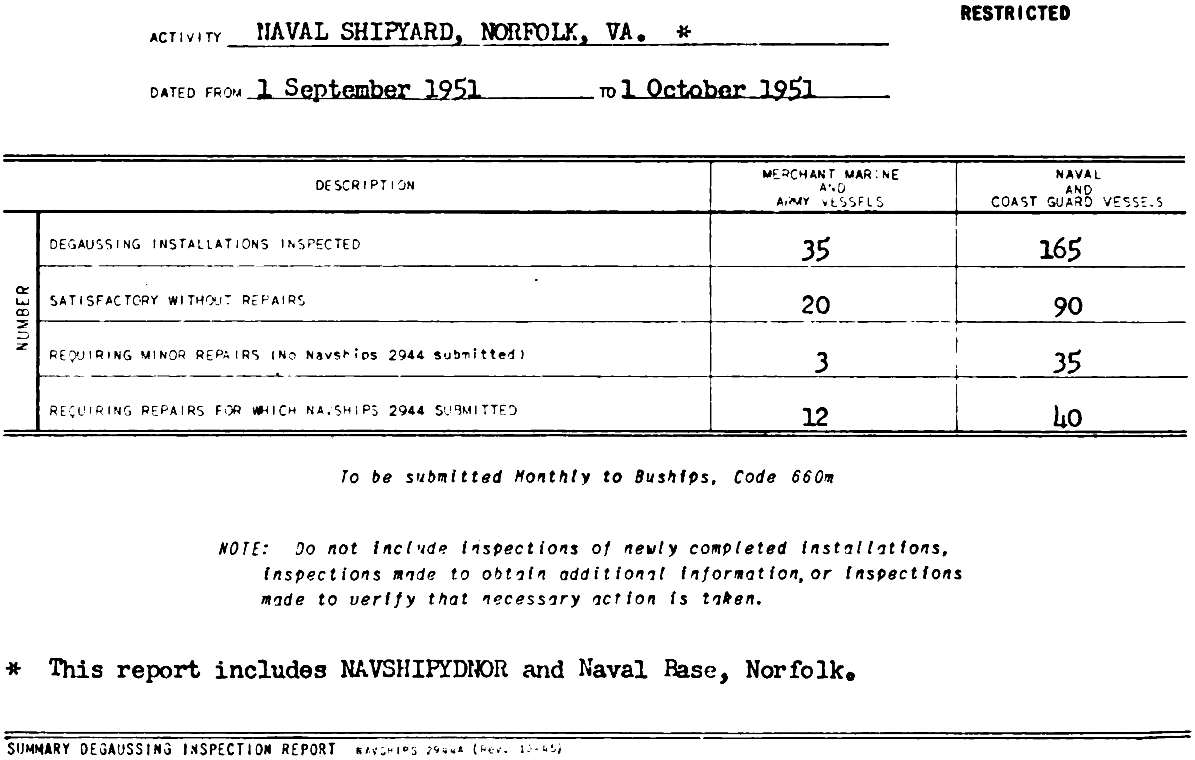
NSPECTION DATE 4 Sept. 1951

INSPECTOR Joseph Blow

5. REMARKS DGP 39 submitted for item 3

GAUSSING REPAIR REPORT NAVSHIPS-2944 (4-45)

Figure 9–1 (a) and (b). Completed NAVSHIPS 2944 forms.



RESTRICTED

ACTIVITY NAVAL SHIPYARD, NORFOLK, VA. *

DATED FROM 1 September 1951 TO 1 October 1951

	DESCRIPTION	MERCHANT MARINE AND ARMY VESSELS	NAVAL AND COAST GUARD VESSELS
NUMBER	DEGAUSSING INSTALLATIONS INSPECTED	35	165
	SATISFACTORY WITHOUT REPAIRS	20	90
	REQUIRING MINOR REPAIRS (No Navships 2944 submitted)	3	35
	REQUIRING REPAIRS FOR WHICH NAVSHIPS 2944 SUBMITTED	12	40

To be submitted Monthly to Bushlps, Code 660m

NOTE: Do not include inspections of newly completed installations, inspections made to obtain additional information, or inspections made to verify that necessary action is taken.

* This report includes NAVSHIPYDNOR and Naval Base, Norfolk.

SUMMARY DEGAUSSING INSPECTION REPORT NAVSHIPS 2944A (Rev. 10-45)

Figure 9–2. Completed NAVSHIPS 2944A form.

ity of the power supply to meet the demand load of the degaussing coils should be determined from the Engineer Officer. He should also see that power is available for such energizing of the coils as will be desired during the inspection.

9-23. PHYSICAL INSPECTION

(1) *Cable runs.* A visual inspection should be made of degaussing cable runs to check for mechanical damage, deteriorated insulation, evidence of overheating, wet places, etc. Stuffing tubes and conduit couplings may not be watertight and allow water to get into the conduit. An especially careful check is needed on cable runs through hazardous locations, magazines, oil and gasoline pump rooms, oil tanks, paint storage rooms, etc., and through crew's quarters and storage and other spaces where cables are subject to mechanical damage. Bilge runs of A coils should be inspected to make sure that the cable is properly protected against immersion in oil and water. Lead covered Type MDGL cable is satisfactory for such runs without conduit. When armored synthetic sheath cables in such locations without watertight conduits are found to be defective, they should be replaced by sections of lead-covered cable if the coil is to be maintained. Defective cable in weather deck locations should be replaced by MDGY type cable.

(2) *Equipment.* All equipment should be checked to make sure that it is not exposed to immersion, spray, drip, falling objects, etc. Necessary actio should be taken to protect the equipment.

(3) *Fuses and switches.* Fuses and switche should be inspected to make sure that they are o the correct size, that switches are in good condition and operate satisfactorily, and that suitabl switch and fuse retainers are installed to secur them against mechanical shock.

(4) *Labels.* All equipment should be labeled t show its use, that is, equipment for each coil shoul be identified with that coil; switch positions shoul be marked; warning and instruction name plat should be in place.

(5) *Contact surfaces.* Electrical contact surface on motor-generator sets and rheostats should b smooth, clean, and free from dirt between segment Brush pressure should be correct. Short circuitin of segments or excessive sparking may be caused b contact surfaces which are not in good conditio When corrective action is necessary on a moto generator set, the action should be in accordan with the instruction book for the set.

(6) *Polarity indicator lamps.* The neon lam (Type T-4½) which are commonly used for pola ity indicator lamps require a 40,000-ohm series r sistor for use on 120-volt circuits and a 120,000-oh series resistor for use on 240-volt circuits. If bulb is burned out, the series resistor should checked with an ohmmeter to see if it has the rig

resistance. A spare lamp should be kept in each indicator light box.

(7) *Discharge resistors.* Discharge resistors of low ohmic value which are used with special contactors and switches having discharge auxiliary contacts should be checked.

(8) *Drain plugs.* Drain plugs should be installed at the low points of connection and through boxes and other watertight enclosures when located where condensate or other water collects in the enclosure. Nonwatertight enclosures should have continuous drainage.

(9) *Supply switch.* If a single-throw supply switch is installed for the FP–QP coil, the switch should be replaced by a three-position reversing switch at the first opportunity.

(10) *Switch position indicator plates.* Vessels having split coil systems with three course heading correction for the FI–QI and A coils should have switch position indicator plates installed at the FI–QI and A coil double-pole, double-throw reversing switches. These plates are shown by the following drawings in chapter 11 of this manual:

Coil	*BUSHIPS drawing No.*
FI–QI	10–T–2702–L
A	10–T–2703–L

Plates should be installed where missing. Plates are stocked at the district degaussing stock depots. Vessels requiring multiple course correction such as AM's and DMS's and installations not of this split coil type should not have these plates installed.

9-24. INSULATION TEST—GENERAL

The insulation resistance of each coil should be measured with an insulation resistance measuring instrument. Full information on the measurement of insulation resistance is to be found in the Bureau of Ships Manual, chapter 60.

9-25. INSULATION TEST—FIRST STEPS

(1) *First step.* (a) The first check of insulation resistance should be made at the supply switch on the degaussing switchboard. The switch should be open to isolate the degaussing coil from the degaussing power supply, but the degaussing coil and its associated control and compass compensating coil equipment should all be connected together. The rheostat arm should be on some current carrying contact, not on the zero current position, to make sure all elements are connected in the circuit. The insulation resistance to ground should be measured from this circuit including all elements. If the measured insulation resistance to ground is satisfactory, all elements are free from objectionable grounds. If the insulation resistance is low, further tests are necessary.

(b) In the case of motor-generator installations in which the degaussing coil feeder conductors are connected directly to the generator terminals instead of going through a supply switch, the first check is made at the generator terminals (or other readily accessible points) without disconnecting the coil from the generator. If the insulation resistance is satisfactory, all elements in the circuits are free from objectionable grounds. If the insulation resistance is low, further tests are necessary.

(2) *Second step.* If the insulation resistance is low, the next step is to separate the degaussing cable from the rest of the equipment, measure the insulation resistance of the parts separately, and determine whether the low resistance to ground is in the degaussing coil cable (see art. 9–26), in the degaussing generator of motor-generator installations or in the control and compass compensating equipment for the degaussing coil (see art. 9–27).

9-26. LOW CABLE INSULATION RESISTANCE

The following points should be considered if the cable insulation resistance is low:

(1) *Physical damage.* Visual inspection may reveal evidence of physical damage which is the cause of low insulation resistance.

(2) *Moisture in cables.* The cables may have absorbed moisture. Heating the cables by running current through them for a period of time (at least 12 hours) may dry the cables enough to increase the insulation resistance to a satisfactory degree. Cable insulation resistance is satisfactory if the insulation resistance per foot is above the minimum value given in fig. 9–3. This figure is taken from the Bureau of Ships Manual, chapter 60, which should be consulted for detailed instructions on how to determine insulation resistance per foot. Note that the minimum insulation resistance per foot depends upon the temperature to a marked degree. Note also that the minimum insulation resistance given by fig. 9–3 is lower than the minimum given by fig. 8–1 in chapter 8. This is because fig. 8-1 is for the minimum insulation resistance of cables in *new* installations, while fig. 9–3 is for cables in installations which have been in use, in some cases for a considerable period of time. For these a lower minimum value is allowed than for new installations.

(3) *Boxes.* Connection or through boxes may be wet or dirty. Such conditions frequently cause low insulation resistance. The boxes should be cleaned and then dried by lamps or heaters. If wet boxes are found, the cause or causes of this condition should be determined and corrected. Loose covers, broken gaskets, leaky stuffing tubes, lack of provision for draining boxes, and so forth may contribute to the entrance and retention of moisture.

(4) *Cellophane markers.* Some multiconductor cables may have individual conductors wrapped with cellophane for identification purposes. Cellophane has low insulation resistance when damp, and low insulation readings will be obtained if such markers make contact with the connection box or connectors. The remedy is to cut away the cellophane markers

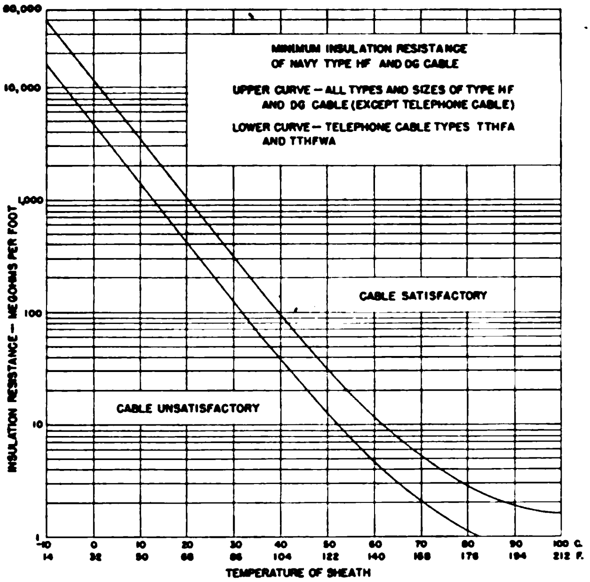


Figure 9-3. Cable insulation resistance as a function of temperature. Minimum values for installations in service.

well back of the conductor end to prevent contact with the box or terminal strip.

(5) *On-deck installations.* On-deck installations are a frequent source of trouble because of flooding of deck boxes, and leaky pipe expansion joints and grip-type pipe couplings which may open under the impact of seas and working of the ship.

(6) *Location of ground.* If correcting the obvious conditions does not eliminate the ground or grounds which cause low insulation resistance, the sections of coil may be progressively isolated until the grounds are found. If there is more than one ground in a coil, the conductors will have to be disconnected and tested one by one.

(7) *Eliminating grounds.* (a) For temporary repairs, grounded conductors can be cut out of the circuit. This will, however, increase current in the remaining conductors; may unbalance parallel circuits; and is not to be considered as anything but a temporary expedient.

(b) When a few conductors are grounded, spare conductors can be substituted, if available. The grounded conductors should be conspicuously labeled "Grounded ____________________", giving the date and name of the activity.

(c) In general, it is better to replace sections of defective cable than to substitute spare conductors. This is particularly true of installations with MDGW cables on a weather deck. Experience has shown that if even one conductor of a weather deck cable is grounded at a point other than a connection box, the cable will usually require replacement before the next scheduled repair period for the vessel. Hence, any defective MDGW cable in weather deck locations should be replaced with MDGY cable when the vessel is available for repairs (generally a week or more).

(d) When any changes in connections are made, extreme care should be taken to make sure that the change will not decrease the protection afforded the vessel by the degaussing installation. Compass compensation should be rechecked as well as the polarities of all coils, loops, and individual conductors.

9-27. GROUND NOT IN CABLE

If the ground is not in the cable, the first step is to ascertain whether it is in the control equipment or circuits or in the compass compensating coil equipment or circuits. The compass compensating coil circuits and equipment should not be disturbed unless it is established that the ground is in them. Any changes or reconnections may necessitate recompensation of the compass compensating coils.

(1) *Control equipment.* Visual inspection should reveal such conditions as mechanical contact or moisture causing a ground. If this does not suffice to locate the ground, isolating the items of control equipment, rheostats, resistors, remote control circuits, motor-generator sets, etc., and measuring the insulation resistance of the separate items will show which is grounded.

(2) *Compass compensating coil equipment.* Mechanical contacts between conductors and a control or junction box and moisture in boxes are often the sources of grounds. Visual inspection will reveal these conditions. The boxes should be dried and checked for watertightness. If visual inspection fails to locate the ground, the elements should be isolated and the insulation resistance measured for each. If the ground is in the compass compensating coil winding, it is best to replace the coil.

9-28. MOTOR-GENERATOR SETS

Motor-generator sets should be inspected and the insulation resistance of the motor and generator measured, if trouble in this unit is indicated. See chapter 60 of the Bureau of Ships Manual for detailed information on insulation resistance measurements, the values of insulation resistance that can be considered satisfactory for motors and generators, and cleaning and repairing motors and generators.

9-29. OPERATING TESTS

Each of the degaussing coils should be energized in turn and the points covered in arts. 9-30 to 9-35 should be checked.

9-30. CURRENT

(1) *Increasing current.* The maximum coil current specified for any latitude or heading by the latest degaussing charts in the degaussing folder should be obtainable. If not, the current can be increased on multiconductor installation by cutting

out some of the series resistance or by lowering the coil resistance by paralleling spare conductors with active conductors.

(a) If a stop has been installed on the rheostat to keep it from reaching zero resistance, the stop can be moved to reduce the resistance. If series resistors are adjusted, care must be taken not to disturb the section of the resistor across which the leads for the compass compensating coils is connected.

(b) If turns are paralleled, the current through each should be checked to make sure that the turns have been correctly connected, that paralleled conductors of the same size and length carry the same current, and that no conductors are overloaded.

(2) *Limiting current.* The maximum current obtainable should not exceed the rating of the ammeter, cable, rheostat, series resistors, motor-generator set, or other equipment.

(a) The current should be limited by series resistors to not more than the safe rating, either by additional series resistors (preferably) or by a stop on the rheostat. On manual type rheostats, a mechanical stop to the contact arm can be installed. On some types of motor-driven rheostats, the cams on the contact arm shaft can be adjusted to operate a limit switch and stop the arm before it reaches the zero resistance position; on other types, the positions of the limit switches can be changed. Ammeters in the circuit should be disconnected or jumped if there is danger of exceeding their current rating while making the adjustments.

(b) In the case of motor-generator set installations, the current is limited by connecting a resistor in series with the generator field rheostat.

9–31. AMPERE TURNS

The ampere turns produced by each coil for a given coil current should be calculated from the current and the number of turns in the coil. The number of turns can be found in the Degaussing Folder. The ampere turns should then be checked using a tong test ampere turn meter.

(1) *Checking the tong test meter.* It should be noted that the tong tester may be inaccurate by as much as 10%. If, however, it is kept calibrated and used correctly, the accuracy should be within 3 to 5%. Means for checking and calibrating the installation should be set up at a suitable place on shore. It is suggested that a loop of a multiconductor cable be rigged up for this purpose. The loop should be large enough so that changing its size and shape does not affect the reading of the tong tester. Passing a known current through a known number of turns will give a known number of ampere turns. The cable should be centered in the instrument loop, and, if possible, the calibration should be made where large amounts of iron are not close to the iron of the instrument. The inspector can experiment to acquaint himself with the errors that may be caused by the presence of iron.

(2) *Measured and calculated ampere turns.* If the measured value of ampere turns is reasonably close to the value calculated from the coil current and the number of turns in the coil, it can be assumed that coil connections are correct. If, however, the measured and calculated values are appreciably different, several things may be at fault, such as reversed turns, shorted turns, omitted turns, grounds, etc. Previous reports from ranges may also indicate that the effect of the coils was not consistent with the current used, a condition which would support the conclusion that there is something at fault in the degaussing installation.

(3) *Checking connections.* (a) Connection and through boxes should be checked if the tong tester measurements or the results of magnetic ranging indicate that the coil connections may be wrong. With the power supply switches open, continuity of circuits and conductors can be checked with an ohmmeter. Conductors not in the coil circuit can be readily identified since they have no connection with the rest of the coil.

(b) With the degaussing coil energized, a voltmeter can be used to find circuit faults. One voltmeter lead is connected to one of the feeder cables, the other is touched successively to the connectors on the terminal strips in a connection box. When all turns are connected correctly, there will be a regular change in voltage as the movable voltmeter lead is advanced from one terminal to the next. If there is a shorted turn, the voltage will not change as the voltmeter lead is moved from the connector on one side of the shorted section to the connector on the other side. In making this test, paralleled conductors should not be mistaken for shorted turns. If there is an omitted turn, the voltmeter reading will drop to zero when the movable voltmeter lead is touched to the connector at either end of the omitted turn. If there is an open turn, the voltmeter will read full line voltage when the movable voltmeter lead is touched to any conductor on one side of the open place; and will read zero on the other side of the open place.

(c) Useful information can also be obtained by touching the voltmeter leads to two adjacent connectors and moving from one pair of adjacent terminals to the next pair. Other methods of using an ohmmeter or a voltmeter to detect faults can be devised.

(d) Reversed turns are best detected by using a tong test meter. To do this it is best to reduce the coil current to about one-third or one-half the maximum value; use a low scale tong test element; then short out one turn at a time and note the effect on the tong tester. An increase in ampere turns when a turn is shorted out means that the turn is reversed; no change indicates an omitted or shorted turn; and a decrease indicates that the turn is connected additive. Occasionally turns are purposely connected in reverse to obtain smaller steps in ampere turns in parallel circuit installations or for resistance reasons. Such turns should not be changed except for very good reasons.

(4) *Changing connections.* Special care must be taken to make sure that the connections are correct after any changes are made. The currents in the branches of parallel circuits should be measured to see that no branch is overloaded. If the design and installation are such that the branches are intended to be identical, the same current should flow in each.

9-32. POLARITY

A check should be made to see that for positive current in a coil the ammeter deflects to the right, the supply switch is thrown up or to the right, and the right hand plate of the neon indicator lamp glows. The direction of coil current should be checked by a small compass or by a polarity indicator. See chapter 2 for detailed information on polarity.

9-33. AMMETERS

Ammeters should be checked to see if the needle operates freely. Sticking ammeters should be replaced if repairs are not feasible. Local and remote ammeters should agree within 3 percent. If they do not, both should be checked against a standard ammeter. Ammeters can be adjusted for variation in lead length by adjusting the resistor provided inside the meter. Ammeters should have a scale suitable for the maximum coil current. If the ammeter scale is over 30 percent larger than the maximum current ever to be used in the coil (except for the FP—QP coil), the ammeter should be replaced with an ammeter of suitable range.

9-34. RHEOSTATS AND POLARITY CHANGERS

The operation of motor-driven rheostats, polarity changers, and generator field rheostats of motor-generator sets should be checked for operation, both manually and by push-button control. Current variation produced by operating rheostats should be smooth and continuous indicating that rheostat elements and contacts are in good condition. Care should be taken when checking motor-operated polarity changers not to operate the load contacts manually when they are carrying more than minimum current. These contacts are not designed for interrupting load currents and such operation will seriously damage the contacts. Current reversal in the polarity changing contacts should take place at minimum current and without appreciable arcing. Defective and improperly functioning parts in rheostats and polarity changers should be replaced.

9-35. COMPASS COMPENSATING COILS

Compass compensating coils should be checked by someone familiar with compensation of these coils. Detailed information on compass compensating coils is given in chapter 6.

9-36.—CAUTION ON MAKING CHANGES

Make no changes in the degaussing installation if such changes might reduce the protection afforded the vessel by the degaussing installation. Investigate all available information to determine the connections that existed at the time the vessel was calibrated. Changes in coil connections may require new coil currents. In case of question, a recommendation should be made to have the connections checked or corrected at the next ranging of the vessel.

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Chapter 10

REDUCTION OF MAGNETIC FIELDS FROM ELECTRIC CIRCUITS AND EQUIPMENT

Section 1. GENERAL

0-1. SCOPE OF THIS CHAPTER

This chapter discusses means of reducing that art of the ship's magnetic field which is due to he stray magnetic fields of its electrical circuits nd machinery. Some conception of the magni- de of stray fields from definite cable arrange- ents is given, and design features desirable in lectrical machinery to minimize stray fields are utlined. This information is for use of Supervi- rs of Shipbuilding, degaussing inspectors, and in- alling yards to ensure that all high current cable ns are laid out to best advantage and that ship- uilder-furnished electrical machinery incorporates hese features in its design. *During the construction nd repair of minesweeping vessels, extreme vigi- nce must be maintained to make sure that the high urrent cable runs are arranged in the manner commended by this chapter.* This also applies the propulsion system on d-c electric drive ships.

-2. SHIP'S MAGNETIC FIELD

(1) The magnetic field of a ship is caused by:

(a) The permanent and induced magnetization the iron and steel or other magnetic material its hull, machinery, or cargo.

(b) The flow of current in electric circuits and achinery.

(2) These two causes are independent and each n operate alone. First consider a steel ship with- t a single electrical circuit or a single piece of ectrical equipment. This ship will have a mag- tic field caused by the permanent and induced agnetization of the steel in its structure. Then nsider a boat which is constructed throughout nonmagnetic materials and is equipped with a werful storage battery (also made of nonmag- tic materials) to operate a searchlight, for ex- ple. Despite the complete absence of nonmag- tic materials, when the searchlight is turned on, e boat will be surrounded by a magnetic field used by the flow of current, and this field will be considerable magnitude if the current is large d the leads from the battery to the searchlight rm a loop which incloses a large area. These o examples illustrate two extreme conditions, both hly unusual. A normal ship has magnetic ma- ial in its hull or machinery, and it also carries electrical equipment. The magnetic field it produces is the resultant of the field caused by magnetization of the magnetic material, and the field caused by current flow in the electrical circuits and equipment.

10-3. FUNCTION OF THE DEGAUSSING INSTALLATION

The function of the degaussing installation that has been described in previous chapters is to counteract or neutralize that part of the ship's field which is caused by magnetization of magnetic materials. In the majority of vessels this is much larger than the magnetic field caused by flow of current in electric circuits and equipment, and is all that need be considered. In some vessels, however, the magnetic field produced by current flow is of importance.

10-4. MAGNETIC FIELDS PRODUCED BY CURRENT FLOW

(1) *When important.* There are two cases when the magnetic fields produced by current flow become a matter of concern:

(a) When the magnetic field produced by current flow is of comparable magnitude to that produced by magnetization of magnetic materials in the ship's hull or machinery, a condition which may arise on ships with powerful electric machinery as, for example, a ship with d-c electric drive.

(b) When the magnetic field produced by current flow is small compared to that produced by magnetization of magnetic material but the use of the vessel, magnetic minesweeping, for example, requires that the magnetic field be made as small as possible.

(2) *Effects produced.* Consider an electric drive ship fitted with a degaussing installation, and suppose that the degaussing installation does a perfect job of counteracting or neutralizing the magnetic field caused by magnetic material. When all electrical equipment (except that associated with the degaussing installation) is idle, the ship will be perfectly degaussed. Now suppose that the electric drive is started. If this produces a large magnetic field, and both theory and tests show that it may, the ship will no longer be perfectly degaussed and may, in fact, be little or no better off than if it had no degaussing installation at all. To avoid this

situation, the electric drive installation must be designed so that the magnetic field it produces is as small as possible. The magnetic field referred to is, of course, the field external to the electric machinery, since powerful magnetic fields will be present inside the machinery when it is running. We have then, two different situations with respect to electrical circuits and machinery, as follows:

(a) The degaussing installation is designed to produce a large magnetic field that is, as nearly as possible, equal and opposite to the magnetic field produced by magnetization of the magnetic materials in the vessel.

(b) The other electrical equipment is intended for purposes other than the production of large external magnetic fields, and should be designed so that the external magnetic field is as small as possible.

Section 2. ELECTRICAL CIRCUITS

10-11. BASIC CONSIDERATIONS

(1) *Theoretical requirements for zero field.* Any electrical circuit can be considered to be a loop which incloses an area determined by the location of the conductors. For the magnetic field of the loop to be zero at all points it is necessary either that:

(a) The current be zero; or

(b) The area of the loop be zero.

(2) *Practical expedients.* Neither of the above conditions can be satisfied in actual installations. The available practical expedients for minimizing magnetic fields from electrical circuits are:

(a) Make the area of each loop as small as possible.

(b) Arrange each loop adjacent to another of the same strength but opposite polarity so that their magnetic fields cancel.

(c) Do not enclose steel or other magnetic materials in a current loop, that is, between conductors.

10-12. CABLE RUNS

(1) *Magnitude of field.* Consider a cable run with two single conductor cables in each leg as indicated in fig. 10-1. Assuming that the current path is closed at each end, it will be seen that the cable run is equivalent to a long narrow loop AB enclosed by a loop CD three times as wide and of the same polarity. The magnetic fields of the two loops add to give a total equal to four times that of the narrow loop. Suppose that the outside diameter of the cables is 1.5 inches, that they are arranged in a horizontal plane touching each other so that the center-to-center distance between adjacent cables is 1.5 inches, that the length of the cable run is 60 feet, and that each cable carries 1,000 amperes (total current 2,000 amperes). The areas of the current loops are as small as they can be when the cables are arranged as indicated in fig. 10-1, and, at first sight, it might seem that the magnetic field from the cable run will be negligible at any appreciable distance. If, however, the magnitude of the magnetic field is calculated, the vertical component of magnetic field at a plane 25 feet above or below the cable run is found to have a maximum value of 5.7 milligauss. This is far too large to be considered negligible in the case of a minesweeper, for example, where it is important to have a magnetic field as small as possible. This example shows that it is not enough to make the area of the current loop as small as possible. Something more is needed when the magnetic field must be negligible.

(2) *Opposing current loops.* Suppose now that the cables are connected as shown in fig. 10-2. There are two current loops of the same strength but opposite polarity and their magnetic fields cancel. The maximum value of the vertical component of magnetic field at a plane 25 feet above or below the cable run is about 0.02 milligauss instead of 5.7 for the arrangement shown in fig. 10-1. Table 10-1 gives results for several other arrangements. In all cases, the cable run is 60 feet long, the cables are 1.5 inches in diameter laid tightly together, and the

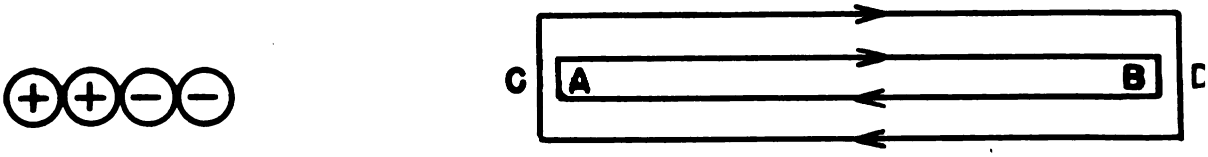

Figure 10-1. Cable run with additive current loops.

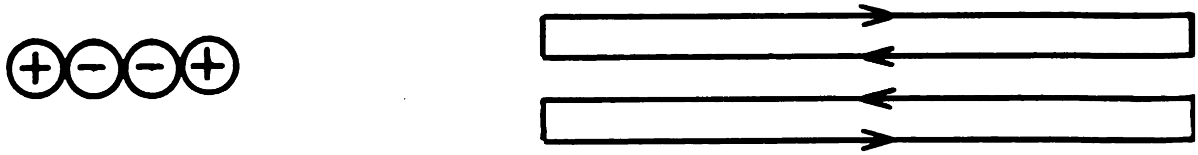

Figure 10-2. Cable run with opposing current loops.

current is 2,000 amperes (1,000 amperes per cable for cable runs with two cables in each leg, and 667 amperes per cable for cable runs with three cables in each leg). The magnetic field is the calculated maximum value of the vertical component at a plane 25 feet above or below the cable. In all cases, the value given is the magnetic field that would be produced in air with no magnetic materials present.

TABLE 10–1

Cable arrangement	Maximum field in milligauss on a plane 25 feet above or below the cable run
(a) + + − −	5.7
(b) + − + −	2.8
(c) + − − +	.02
(d) + + − −	1.5
(e) + − + −	2.8
(f) + − − +	.01
(g) + + + − − −	8.5
(h) + − + − + −	2.8
(i) + − − + − +	.9
(j) + + + − − −	1.5
(k) + − + − + −	.5

(3) *Even or odd number of cables in each leg.* When there is an even number of single conductor cables in each leg of a cable run, the plus and minus cables can be grouped to make an even number of cable loops of which half can be made to have one polarity and the other half the opposite polarity. The result is quite satisfactory cancellation of magnetic fields and a small resultant field, as shown by arrangements (c) and (f) of table 10–1. If, however, there is an odd number of single conductor cables in each leg, there will be an odd number of cable loops and one more loop of one polarity than of the opposite polarity. The resultant field is considerably greater than where there is an even number of cables in each leg, as shown by arrangements (i) and (k) of table 10–1. For this reason, there should be an even number of cables in each leg when single conductor cables are used for the cable run and it is necessary to make the magnetic field from the cable run as small as possible.

(4) *Double conductor cables.* When one double conductor cable is used for a direct-current cable run, one conductor is necessarily plus and the other minus. The conductors are not only close together but are transposed at regular intervals because of the twist of the conductors to form the lay of the cable, and the resulting magnetic field should be small. When the current is large enough to require the use of several double conductor cables in a cable run, two for example, there are two ways of connecting the conductors: use one conductor in each cable for the positive leg of the cable run and the other conductors for the negative leg, or connect the two conductors in each cable in parallel and use one cable for the positive leg and the other for the negative leg. The first alternative gives a much smaller magnetic field and should be used.

10–13. CURRENT LOOPS OTHER THAN IN CABLE RUNS

In addition to those in cable runs, current loops are also found in control panels for electric drive ships, minesweeping panels, terminal boxes for minesweepers where connection is made to the minesweeping cable, and elsewhere. When it is important to make the magnetic field small, each individual loop should be made as small as possible. Even this is not always enough, for as shown by the example in art. 10–12, when the current is of the order of thousands of amperes, even a fairly small loop can give rise to a substantial magnetic field. It is then necessary to arrange opposing current loops so that their magnetic fields cancel as completely as possible.

Section 3. ELECTRICAL EQUIPMENT

10–21. EXTERNAL MAGNETIC FIELDS FROM MOTORS AND GENERATORS

Large motors and generators may give rise to large external magnetic fields. Fortunately this is not an inherent characteristic, as generators and motors can be designed to have only a small external magnetic field.

10–22. INTERPOLE CONNECTIONS WHICH GIVE LARGE EXTERNAL MAGNETIC FIELD

The major source of external magnetic field from d-c motors and generators is longitudinal magnetization of the shaft of the machine. Consider a d-c machine in which the interpoles or commutating poles are connected as shown in figure 10–3. The interpoles are connected in series with the

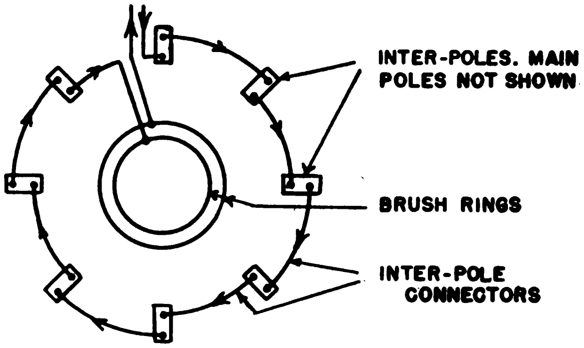

Figure 10–3. Interpole connections which give large external magnetic field.

armature and carry the armature current. When the interpoles are connected as shown in figure 10–3, the armature current makes one complete turn about the shaft of the machine and magnetizes the shaft in a longitudinal direction. Since the armature current of a large d-c machine used for ship propulsion or magnetic minesweeping is of the order of thousands of amperes, it is to be expected that the current will exert a powerful magnetizing effect and that large magnetic fields will exist external to the generator. Numerous test results verify this expectation. A machine with connections as shown in figure 10–3 should never be used when it is important that the external magnetic field be small.

10–23. INTERPOLE CONNECTIONS WHICH GIVE SMALL EXTERNAL MAGNETIC FIELD

(1) *Parallel interpole circuits.* Figure 10–4 shows two interpole circuits in parallel. Half the interpoles are connected in one circuit, half in the other. Half the armature current makes one turn around the shaft in a clockwise direction, the other half makes one turn in the opposite direction. The net magnetizing effect is small if the two interpole circuits are balanced electrically so that the armature current divides equally, and if the connectors in the two circuits are at the same end of the machine as close together as feasible.

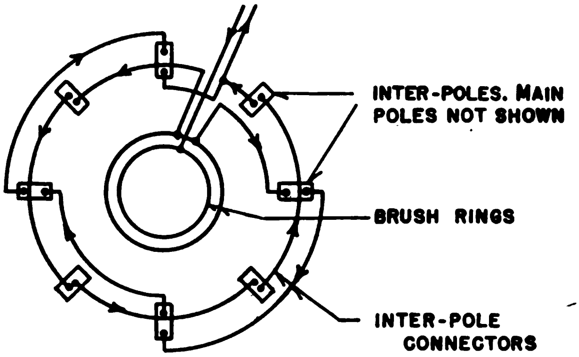

Figure 10–4. Parallel connection of interpole circuits which gives small external magnetic field.

(2) *Series interpole connection.* Figure 10–5 shows all the interpoles connected in one series circuit which goes around the shaft in one direction picking up half the interpoles, and then loops back on itself picking up the other half. The net magnetizing effect is small if the interpole connectors are arranged close to each other. The series circuit arrangement of figure 10–5 has an important advantage over the parallel circuit arrangement of figure 10–4. In the parallel circuit arrangement, the armature current must divide equally between two parallel circuits to balance out the magnetizing effect on the shaft. Changes in resistance of bolted contacts may bring about departures from equal current division and disturb the balance between two opposing magnetizing forces. This possibility does not arise in the series arrangement, since the current is the same in all parts of a series circuit.

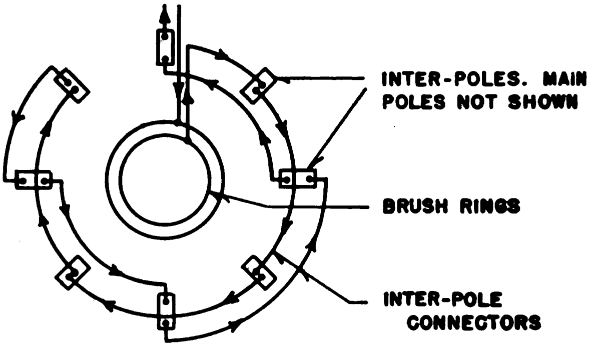

Figure 10–5. Series connection of interpole circuits which gives small external magnetic field.

10–24. COMPENSATING AND SERIES WINDINGS

Some machines have compensating and/or series windings. These windings also carry armature current and can cause longitudinal magnetization of the shaft. The considerations which apply to compensating and series windings are similar to those which apply to the interpole winding.

10–25. BRUSH RINGS

The armature current of a d-c machine does not, in general, divide equally between the different sets of brushes. In addition, the division of current is not constant but changes from time to time. To minimize the possibility that such fluctuations may give rise to longitudinal magnetization of the shaft, brush rings should be completely closed rings of uniform cross section and resistance throughout.

10–26. OTHER MAGNETIC EFFECTS

Experience indicates that when motors and generators are designed to eliminate longitudinal magnetization of the shaft, the remaining external magnetic field is usually too small to make trouble except for minesweepers where the smallest possible magnetic field is necessary. In such cases, even though the residual magnetic field left after elimination of shaft magnetization is small, it is large enough to require additional design precautions. As these are of a specialized nature, they will not be discussed here.

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Chapter 11

DEGAUSSING PUBLICATIONS AND PLANS

11-1. PUBLICATIONS

Publications which contain information relating to the degaussing installation are listed below in tables 11-1 to 11-3.

TABLE 11-1. *Publications relating to cable*

Cable Comparison Guide. NAVSHIPS 250-660-23.

Electric Cables (Shipboard use). Military Specification MIL-C-915.

Electric Cables (Reduced Diameter Types). Military Specification MIL-C-2194.

Merchant Degaussing Cable. Navy Department Specification 15C7.

TABLE 11-2. *Publications relating to compass compensating coil equipment*

General Information—"Adjustment and Compensation" H. O. No. 226 dated April 1944.

Type "K" Coils—"Installation Data" NAVSHIPS (660g) S81-6 dated 10 November 1943.

Type "K" Coils—"Maintenance and Compensation Data" NAVSHIPS (660g) S81-6 dated 1 May 1944.

Type "K-1" Coils—"Installation Data" NAVSHIPS (660g) S81-6 dated 1 February 1945.

"Type "K-1" Coils—"Maintenance and Compensation Data" NAVSHIPS (660g) S81-6 dated 15 February 1945.

Type "T" Coils—"Installation and Compensation Data" NAVSHIPS (660g) S81-6 dated 1 July 1944.

TABLE 11-3. *Publications relating to other aspects of degaussing installations and equipment*

Bureau of Ordnance Publication OP1523—Forms, Records and Reporting Procedures.

Bureau of Ordnance Degaussing Summary List.

Bureau of Ordnance Degaussing Watch List.

Bureau of Ships Manual.

Bureau of Ships Standard Drawing and Stock Catalog Number Index. Bureau of Ships Plan No. 9000-S6000-73387-Alt. 2.

General Specifications for Machinery for Vessels of the United States Navy.

11-2. REFERENCE PLANS

The plans listed in table 11-4 show various items of degaussing equipment and methods of installation. Copies of these plans are not included in the *Degaussing Manual*. If copies of these plans are not available at an activity concerned with the installation of degaussing equipment, copies should be obtained from the Bureau of Ships.

TABLE 11-4.—*Reference plans*

	BuShips Plan No.	Revision or alteration No.
Cable end sealing:		
Sealing Ends of Cable on Reel after Cutting	9-S-3930—L (Sht. 42)	27
Sealing Cable Ends	9-S-5357—L	9
Cable Supports and Protective Enclosures:		
Cable clamp Type C	S6202-73241	0
Methods of Supporting Cables, Fixtures, Panels, Appliances, etc. for Steel and Aluminum Decks and Bulkheads.	9-S-3930-L	27
Single Cable Straps for N. W. T. Decks and Bulkheads	9-S-4442-L	10
Single Cable Straps for W. T. Decks and Bulkheads	9-S-4441-L	11
Suggested Protective Enclosure for Merchant Marine Degaussing Cable	10-T-2590-L	0
Compass Coils and Control Boxes:		
Type "A" Control Box, Six-Lug	S8106-672388	0
Type "A" Terminal Box—Construction Details	10-T-2166-L	0
Type "K" Coil—Assembly and Dimensions	S8106-435094 (Sht. 43)	0
Type "K-1" Coil—Assembly and Dimensions	S8106-718451	0
Type "T" Coil—Assembly and Dimensions	S8106-544487	0
Connection Boxes:		
Connection Box, W. T. 20 Wire for Degaussing Cables	9000-S8106-73142	2
Connection Box, W. T. 40 Wire for Degaussing Cables	9000-S8106-73143	2
Connection Box, W. T. 60 Wire for Degaussing Cables	9000-S8106-73144	2
Connection Box, W. T. 80 Wire for Degaussing Cables	9000-S8106-73145	2
Degaussing Control Units:		
Types S5A and S5B Multiple Resistor Degaussing Control Unit	10-T-2637-L	0
Type LA2470 Degaussing Reverse Turns Controller	S6202-11124	0
Type LA2470 Degaussing Reverse Turns Controller External Wiring Diagram	S6202-11125	0
Type LA2470 Degaussing Reverse Turns Controller Schematic Wiring Diagram	S6202-11126	0
Type LA2470 Degaussing Reverse Turns Controller Wiring Diagrams	S6202-11127	0
Rheostats and Resistors:		
See list of plans Chapter 4, art. 4-68 (2).		
Stuffing Tubes, Bushings, Fitters:		
Bushings for Electrical Conductors Type 4	9-S-4268-L	9
Fitters for Stuffing Tubes Types 51, 52, 53 and 55	9-S-5355-L	9
Method of Installation of Type 52 Terminal Tubes	9-S-5425-L	3
Split Stuffing Tubes for Repair Installations	9-S-4436-L	10
Stuffing Tubes for Degaussing Systems for Merchant Vessels	10-T-2513-L	4
Stuffing Tubes for Degaussing Systems for Merchant Vessels	10-T-2682-L	4

TABLE 11-4.—*Reference plans*—Continued

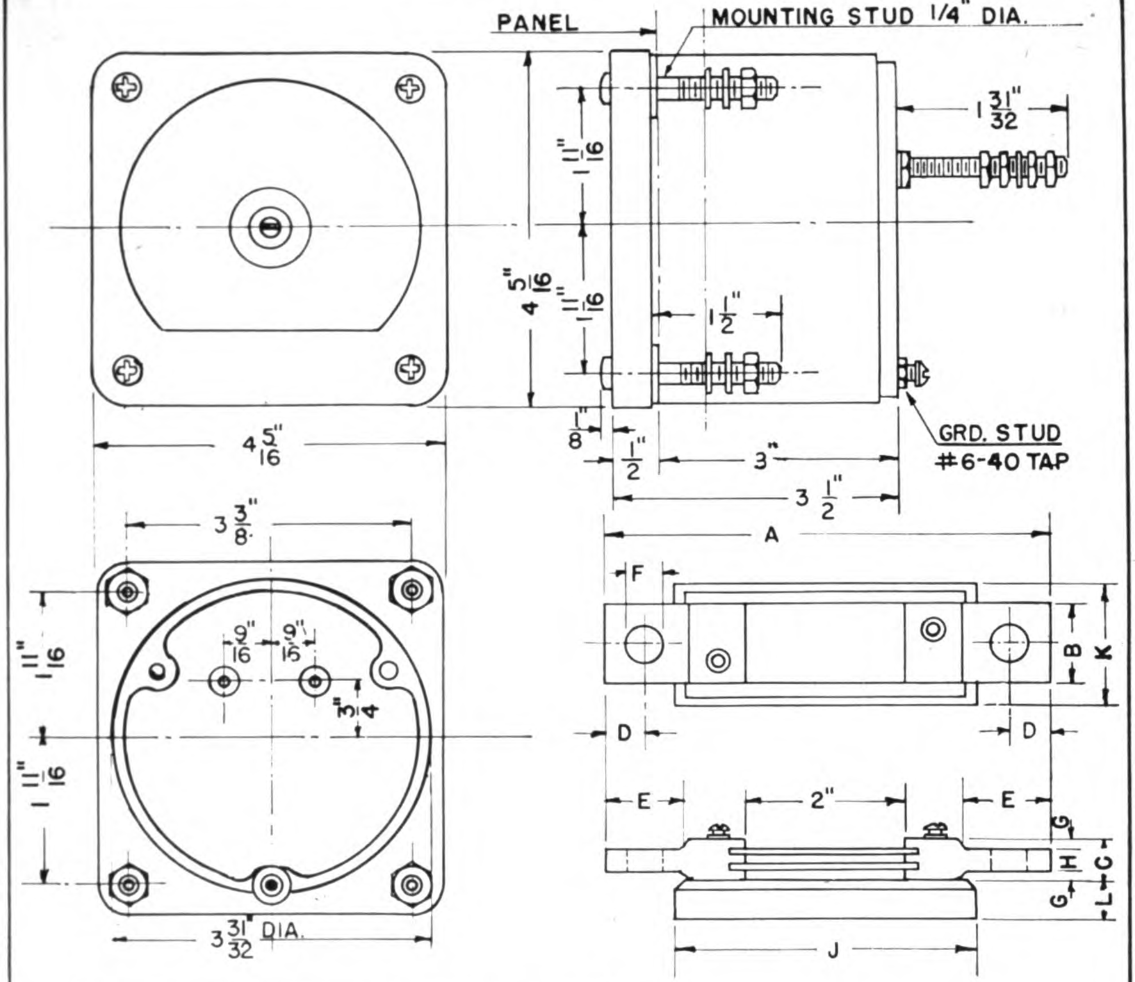
	BuShips Plan No.	Revision or alteration No.
Stuffing Tubes, Bushings, Fitters—Continued		
Stuffing Tubes for Degaussing Systems for Merchant Vessels (Size YM)	S8106-465946	2
Stuffing Tubes (Aluminum) Types 64 and 65	9000-S6202-74121	0
Stuffing Tubes (Steel) Type 46-1	9-S-5100-L	10
Stuffing Tubes Types 30-2A, 48-5, 48-6	9-S-5166-L	14
Stuffing Tubes Types 51, 51-B, 52, 52-B	9-S-5235-L	15
Terminal Tubes (Steel) Type 59 (Alternate)	9-S-5457-L	7
Switches:		
30 Amp DPDT Rotary Snap Switch	9-S-5194-L	6
30 Amp DPDT Rotary Snap Switch	9-S-5471-L	2
25 Amp DPDT Rotary Snap Switch	9000-S6202-73235	1
25 Amp DPDT Rotary Snap Switch	9000-S6202-73262	1
25 Amp DPST Rotary Snap Switch	9-S-5338-L	4
25 Amp TPDT Rotary Snap Switch	9-S-5514-L	3
30 Amp TPDT Rotary Snap Switch	9-S-5468-L	1
25 Amp TPDT Rotary Snap Switch	9000-S6202-73236	1
30 Amp TPST Rotary Snap Switch	9-S-5265-L	6
25 Amp TPST Rotary Snap Switch	9-S-5403-L	2
60 Amp TPDT Rotary Snap Switch	9-S-5469-L	2
60 Amp TPDT Rotary Snap Switch	9-S-5513-L	0
60 Amp TPST Rotary Snap Switch	9-S-5363-L	0
60 Amp TPST Rotary Snap Switch	9000-S6202-73750	0
60 Amp 4PDT Rotary Snap Switch	9000-S6202-73102	1
100 Amp TPDT Rotary Snap Switch	9000-S6202-73188	0
100 Amp TPST Rotary Snap Switch	9-S-5360-L	0
200 Amp DPDT Rotary Snap Switch	9000-S6202-73319	2
200 Amp DPDT Rotary Snap Switch	9000-S6202-73336	3
200 Amp TPST Rotary Snap Switch	9000-S6202-73201	0
200 Amp DPDT Rotary Snap Switch	9000-S6202-73204	1
See list of plans Chapter 5, Art. 5-55 for additional switches.		
Terminal Strips, Connectors, Terminals, Lugs:		
Fabricated Terminals for Electrical Fittings (Closed End)	9000-S6202-73055	7
Fabricated Terminals for Electrical Fittings (Open End)	9000-S6202-73246	3
Lugs for Bus Bars	9000-S6202-73275	3
Lugs for Bus Bars, Solder Type (2 Bolt Holes)	9-S-4435-L	8
Lugs for Round Studs, Punched Tube Type (1 Bolt Hole)	9-S-3808-L	7
Lug Terminals, solder type	9-S-1841-L	34
Method of Mounting 17 Conductor Terminal Strip in Standard Degaussing Connection Boxes.	S8106-699598	0
Terminal Strip for Merchant Marine D. G. (17 connector)	S8106-604626	0
Terminal Strip for No. 9 AWG, Wire, Merchant Marine D. G. (19 connector)	S8106-450534	0
Two Wire Tap Connector for Merchant Marine Degaussing (12 connector)	10-T-2589-L	1
Two Wire Parallel Tap Connectors for Merchant Vessel Degaussing Circuits	10-T-2331-L	1

11-3. DEGAUSSING PLANS INCLUDED IN THE DEGAUSSING MANUAL

The degaussing plans listed in Table 11-5 are included in the Degaussing Manual, immediately after Table 11-5, so as to be available for ready reference.

Table 11-5. Degaussing plans included in the Degaussing Manual

	BuShips Plan No.	Revision or alteration No.
Ammeters:		
Hi-shock ammeters—mounting dimensions	S8106-606016	0
Cable:		
Method of entering types MDGY and MDGW degaussing cables into through or connection boxes.	10-T-2714-L	2
Connection Boxes:		
See Cable.		
Indicator lights:		
Details of degaussing indicator light	S81-920	3
Motor-Generator Sets:		
Elementary one line wiring diagram without remote motor control—typical for one, four-unit two-generator degaussing motor generator with 440-volt or 220-volt, 3 phase, a-c motor. 11 sheets.	10-T-2361-L	1
Rheostats and Resistors:		
Degaussing control rheostats and resistors—120 volts d-c	10-T-2010-L	5
Degaussing resistor	S6202-3,002,159	0
Dimensions for degaussing control rheostats and resistors—240 volts d-c	10-T-2544-L	1
Hi-shock rheostats for degaussing—120 volts d-c	S8106-475153	0
Installation details for HI-shock degaussing rheostats—120 and 240 volts d-c	S8106-756851	1
Multicircuit degaussing rheostat—Navy Type HI-1460	S6202-76028	1
Multicircuit degaussing rheostat—Navy Type HI-2460	10-T-3186-L	2
Switch Position Indicator Cards:		
A coil degaussing switch position indicator	10-T-2703-L	2
FI-QI coil degaussing installation switch position indicator card	10-T-2702-L	2
Wiring Diagrams for Degaussing Installations:		
Split-coil system degaussing installation—elementary wiring diagram	10-T-2701-L	4
Split-coil system degaussing installation—elementary wiring diagram (M-G set and single conductor cable for M coil).	10-T-2873-L	2
Wiring diagram for merchant ship M coil D. G. system	10-T-2863-L	2
Wiring diagram for merchant ship split-coil degaussing	10-T-2860-L	4



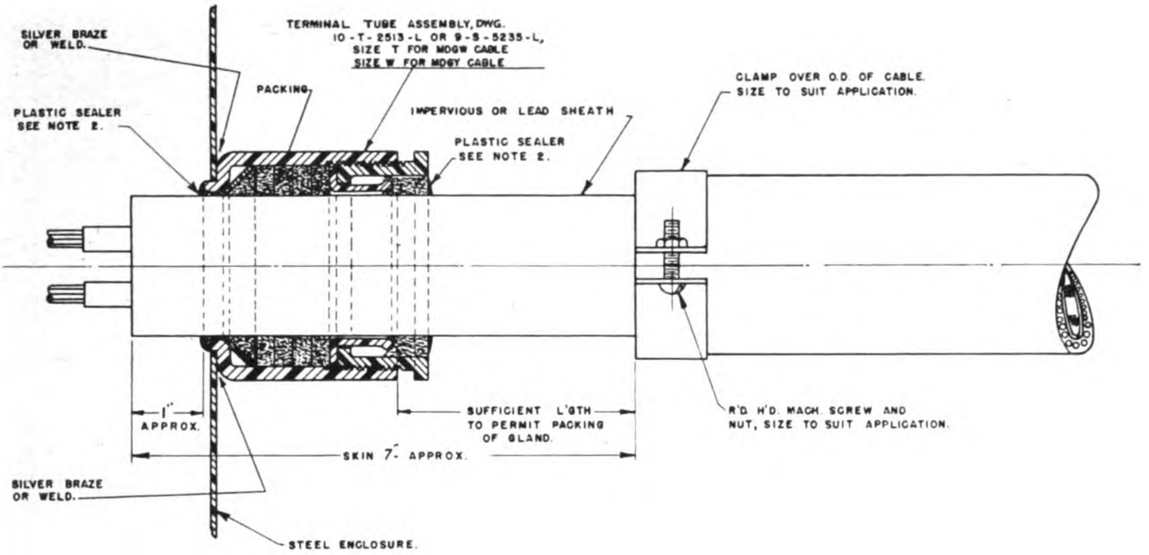
	SHUNT DIMENSIONS										
AMPS	A	B	C	D	E	F	G	H	J	K	L
1 TO 60	$5\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{29}{32}$	$\frac{11}{32}$	$\frac{1}{8}$	$\frac{1}{4}$	$3\frac{11}{16}$	$1\frac{1}{2}$	$\frac{1}{2}$
75	$6\frac{1}{4}$	$1\frac{1}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$1\frac{9}{32}$	$\frac{13}{32}$	$\frac{1}{8}$	$\frac{1}{4}$	$3\frac{11}{16}$	$1\frac{1}{2}$	$\frac{1}{2}$
80	$6\frac{1}{4}$	$1\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$1\frac{9}{32}$	$\frac{13}{32}$	$\frac{1}{8}$	$\frac{1}{4}$	$3\frac{11}{16}$	$1\frac{1}{2}$	$\frac{1}{2}$
100	$6\frac{1}{4}$	$1\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$1\frac{9}{32}$	$\frac{13}{32}$	$\frac{1}{8}$	$\frac{1}{4}$	$3\frac{11}{16}$	$1\frac{3}{4}$	$\frac{1}{2}$
150	$6\frac{3}{4}$	$1\frac{1}{2}$	$\frac{11}{16}$	$\frac{3}{4}$	$1\frac{17}{32}$	$\frac{17}{32}$	$\frac{7}{32}$	$\frac{1}{4}$	$3\frac{11}{16}$	2	$\frac{1}{2}$
200	$6\frac{3}{4}$	$1\frac{1}{2}$	$\frac{7}{8}$	$\frac{3}{4}$	$1\frac{17}{32}$	$\frac{17}{32}$	$\frac{5}{16}$	$\frac{1}{4}$	$3\frac{11}{16}$	2	$\frac{1}{2}$
250	$6\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{16}$	$\frac{3}{4}$	$1\frac{17}{32}$	$\frac{17}{32}$	$\frac{13}{32}$	$\frac{1}{4}$	$3\frac{11}{16}$	2	$\frac{1}{2}$
300	$6\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$\frac{3}{4}$	$1\frac{17}{32}$	$\frac{17}{32}$	$\frac{1}{2}$	$\frac{1}{4}$	$3\frac{11}{16}$	2	$\frac{1}{2}$
400	$8\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{5}{8}$	1	$2\frac{3}{16}$	$\frac{17}{32}$	$\frac{5}{8}$	$\frac{3}{8}$	$4\frac{1}{8}$	$2\frac{1}{2}$	$\frac{3}{4}$
500	$8\frac{1}{4}$	$1\frac{7}{8}$	$1\frac{5}{8}$	1	$2\frac{3}{16}$	$\frac{17}{32}$	$\frac{5}{8}$	$\frac{3}{8}$	$4\frac{1}{8}$	$2\frac{1}{2}$	$\frac{3}{4}$
600	$8\frac{1}{4}$	2	$1\frac{13}{16}$	1	$2\frac{3}{16}$	$\frac{21}{32}$	$\frac{23}{32}$	$\frac{3}{8}$	$4\frac{1}{8}$	3	$\frac{3}{4}$
800	$8\frac{1}{4}$	$2\frac{3}{8}$	2	1	$2\frac{3}{16}$	$\frac{21}{32}$	$\frac{13}{16}$	$\frac{3}{8}$	$4\frac{1}{8}$	3	$\frac{3}{4}$

ALT.	DESCRIPTION	DATE
	ALTERATIONS	

HI-SHOCK AMMETERS
MOUNTING DIMENSIONS

BUREAU OF SHIPS
NAVY DEPARTMENT
WASHINGTON, D.C. JUNE 20, 1944

INDEX	FILE NO.	ALT.
S8106	606016	


SILVER BRAZE OR WELD.
TERMINAL TUBE ASSEMBLY, DWG. 10-T-2513-L OR 9-S-5235-L, SIZE T FOR MDGW CABLE SIZE W FOR MDGY CABLE
PACKING
PLASTIC SEALER SEE NOTE 2.
IMPERVIOUS OR LEAD SHEATH
PLASTIC SEALER SEE NOTE 2.
CLAMP OVER O.D. OF CABLE. SIZE TO SUIT APPLICATION.
1" APPROX.
SUFFICIENT L'GTH TO PERMIT PACKING OF GLAND.
R'D. H'D. MACH. SCREW AND NUT, SIZE TO SUIT APPLICATION.
SKIN 7" APPROX.
SILVER BRAZE OR WELD.
STEEL ENCLOSURE.

NOTES:

1. HOLES FOR TERMINAL TUBES SHALL BE CUT OR DRILLED BY THE MANUFACTURER OR BY THE SHIPBUILDER AS DIRECTED; THESE HOLES SHALL BE SMOOTH AND TRUE WITHOUT ANY DISTORTION OF THE BOX. TERMINAL TUBES SHALL BE ASSEMBLED BY CONTINUOUS TYPE WELD OR BY SILVER BRAZING, AND WITHOUT WARPING OR DISTORTION OF BOX. SEE DR'G. 9-S-5235-L FOR BRAZING DATA.
2. THE SPACE AROUND THE CABLE WITHIN THE GLAND NUT OF ALL TERMINAL TUBES AND ALSO WITHIN THE OPEN END, SHALL BE FILLED WITH PLASTIC SEALER ELECTRICAL INSULATION, CONFORMING TO N.D. SPEC. 17-I-13, AFTER THE TUBES ARE PACKED AND THE GLAND NUTS SET UP.
3. PACKING FOR TERMINAL TUBES SHALL BE OF APPROVED TYPE. FLAX PACKING NOT APPROVED.
4. SPECIFICATIONS LISTED ON THIS PLAN ARE APPLICABLE TO NAVAL INSTALLATIONS ONLY.

NO	REMARKS	DATE	FOR SECT.	[illegible]
2	SIZE "W" TUBE AND MDGY CABLE ADDED	2-20-43	[illegible]	T.E.C.

NO.	PART	REMARKS	BU. LETTER	DATE	INIT.
1		TRACED ON CLOTH		3/6/43	T.E.C.

ALTERATIONS

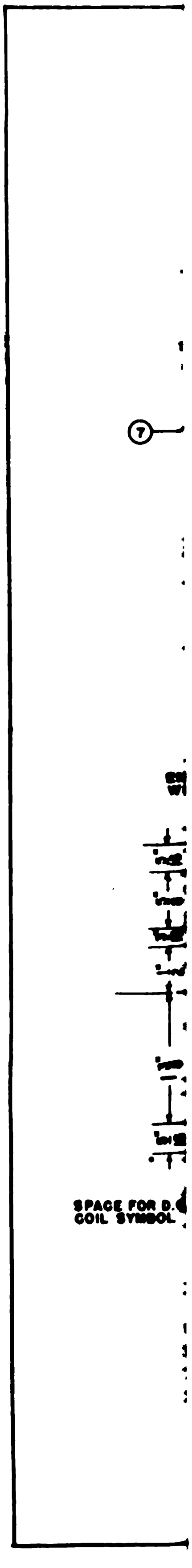
METHOD
OF
ENTERING TYPES MDGY AND MDGW DEGAUSSING CABLES INTO THROUGH OR CONNECTION BOXES

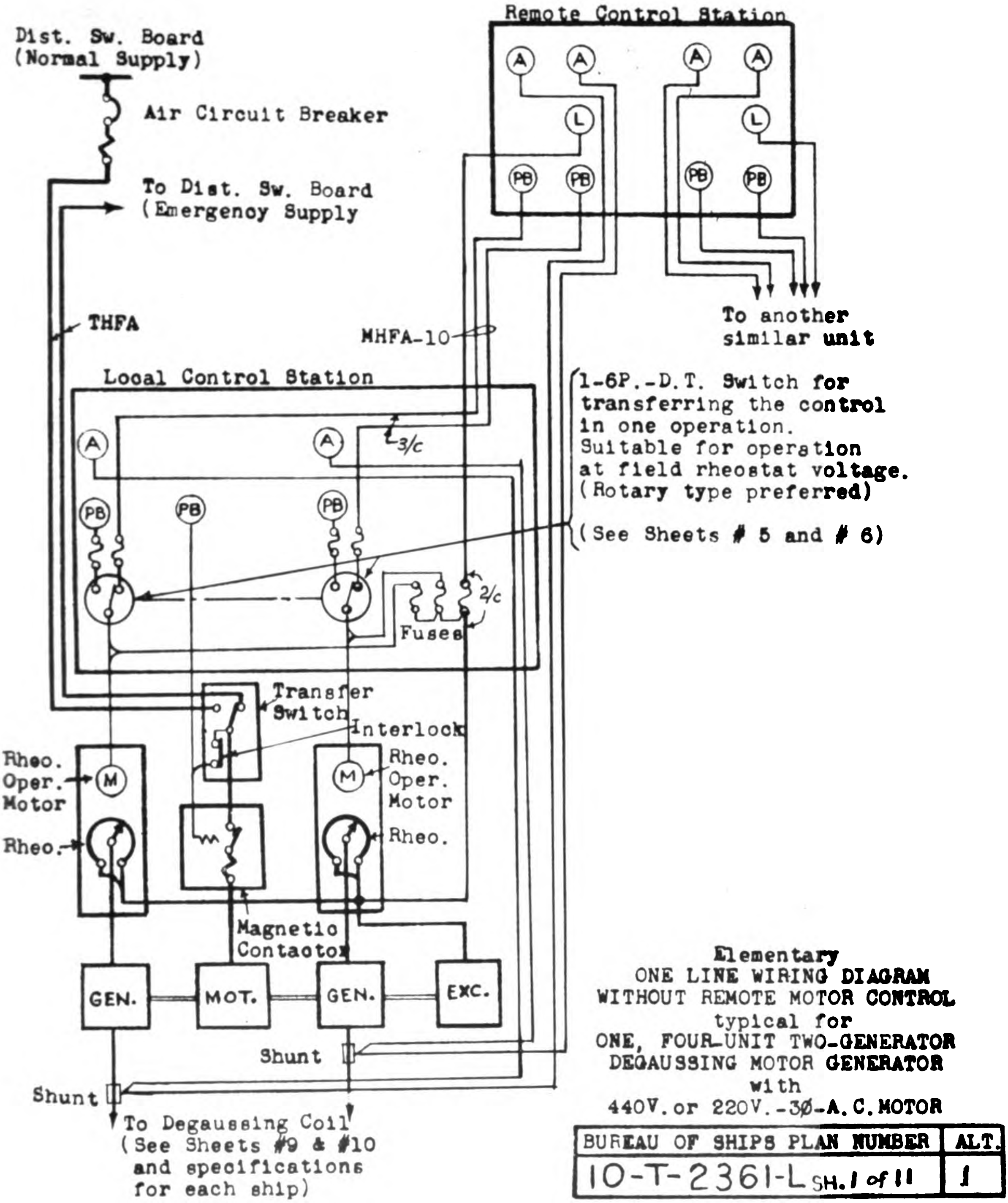
SCALE.... 12 INCHES = 1 FOOT.

BUREAU OF SHIPS,
NAVY DEPARTMENT,
Washington, D. C., October 28, 1942

FOR CHIEF OF BUREAU

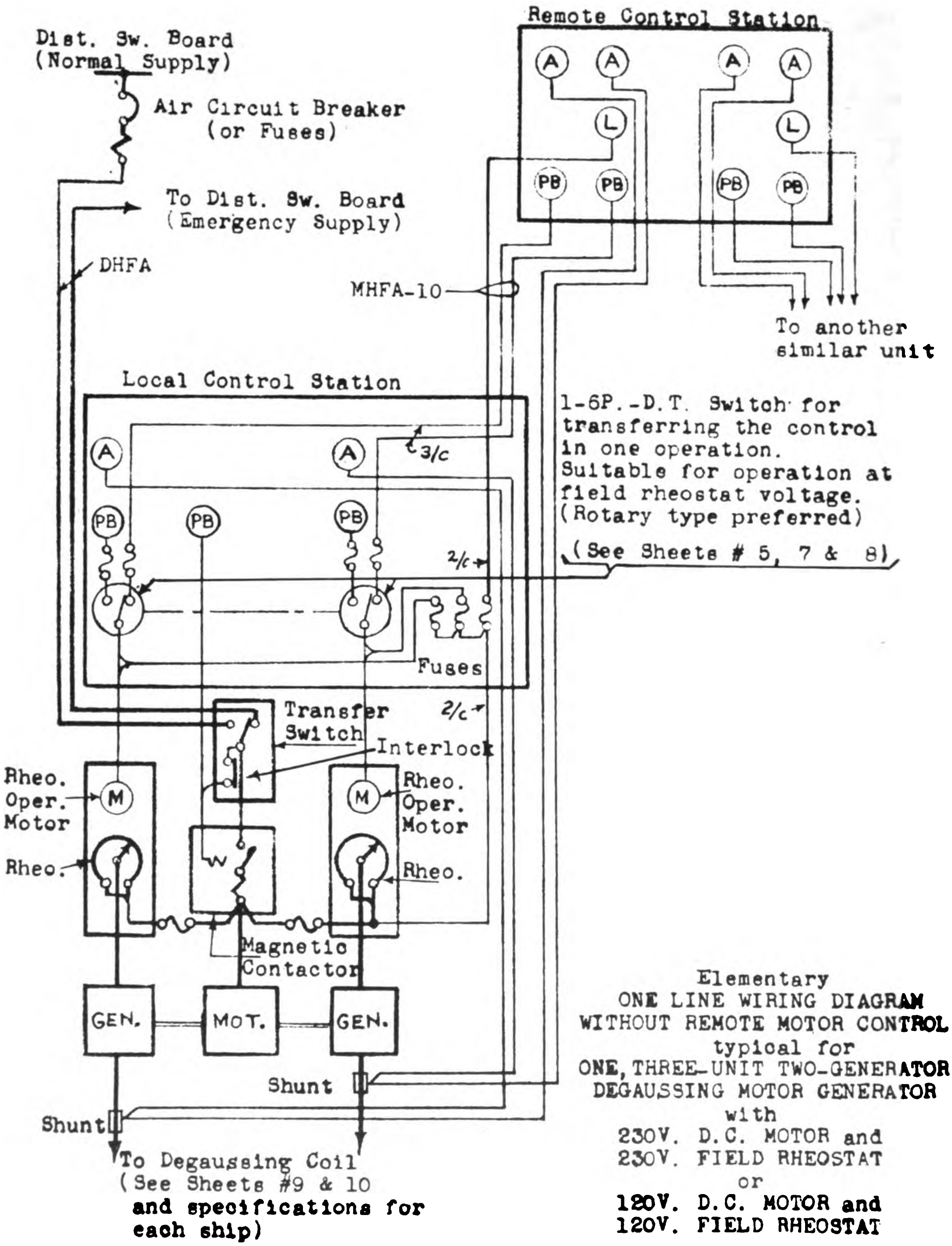
DRAWN BY A. Holland TRACED BY NIGHT LIGHT [illegible] INSPECTED BY HINTZ HEAD ENG'R T.E. Conn[illegible] HEAD OF DIV.	INDEX	GROUP	FILE NO.
	10	T	2714-L-AN 2


7
SPACE FOR D.C
COIL SYMBOL



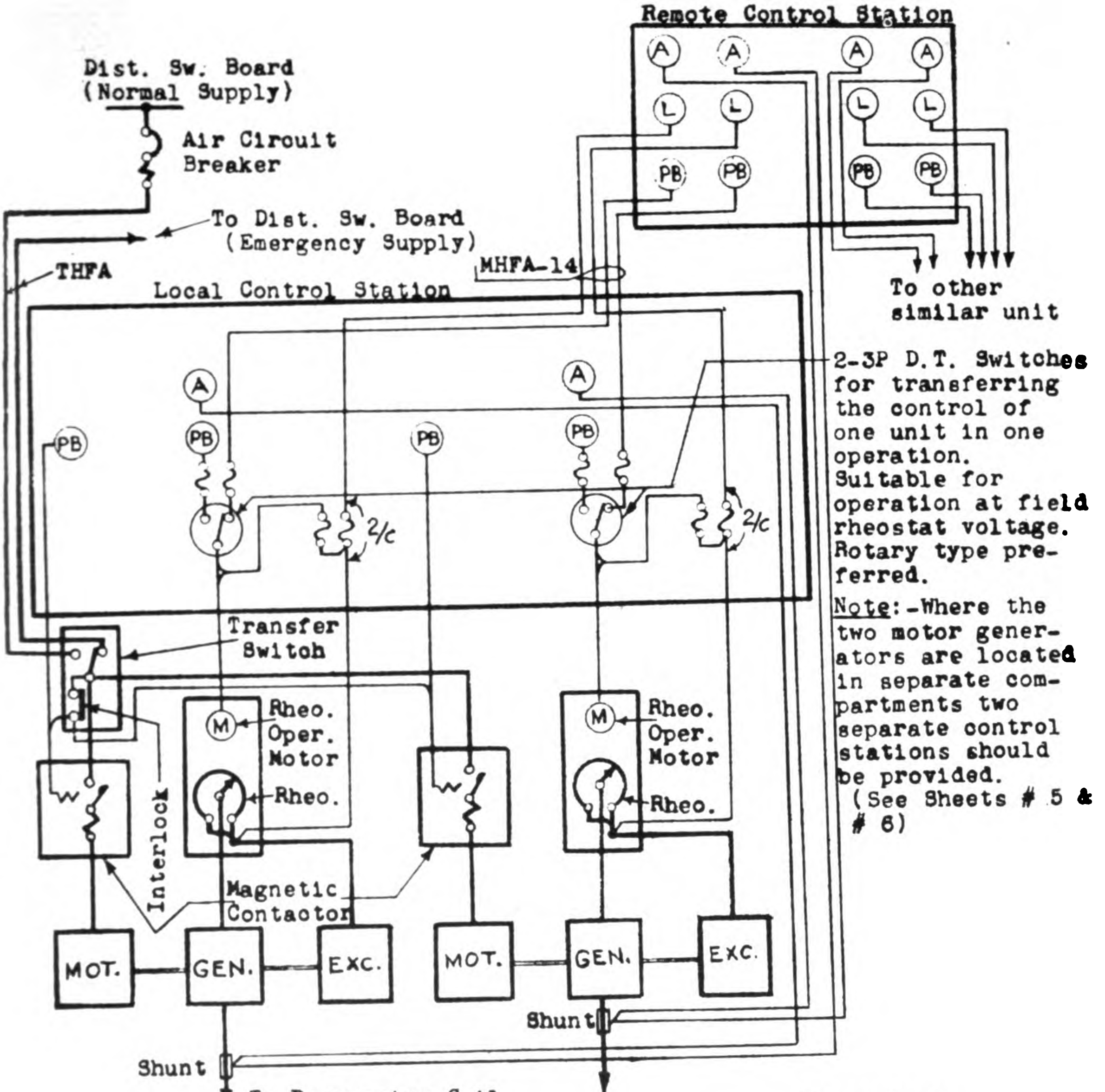
Elementary
ONE LINE WIRING DIAGRAM
WITHOUT REMOTE MOTOR CONTROL
typical for
ONE, FOUR-UNIT TWO-GENERATOR
DEGAUSSING MOTOR GENERATOR
with
440V. or 220V. -30-A. C. MOTOR

BUREAU OF SHIPS PLAN NUMBER	ALT.
10-T-2361-L SH. 1 of 11	1



Elementary
ONE LINE WIRING DIAGRAM
WITHOUT REMOTE MOTOR CONTROL
typical for
ONE, THREE-UNIT TWO-GENERATOR
DEGAUSSING MOTOR GENERATOR
with
230V. D.C. MOTOR and
230V. FIELD RHEOSTAT
or
120V. D.C. MOTOR and
120V. FIELD RHEOSTAT

BUREAU OF SHIPS PLAN NUMBER	ALT.
10-T-2361-L SH.2 of 11	1



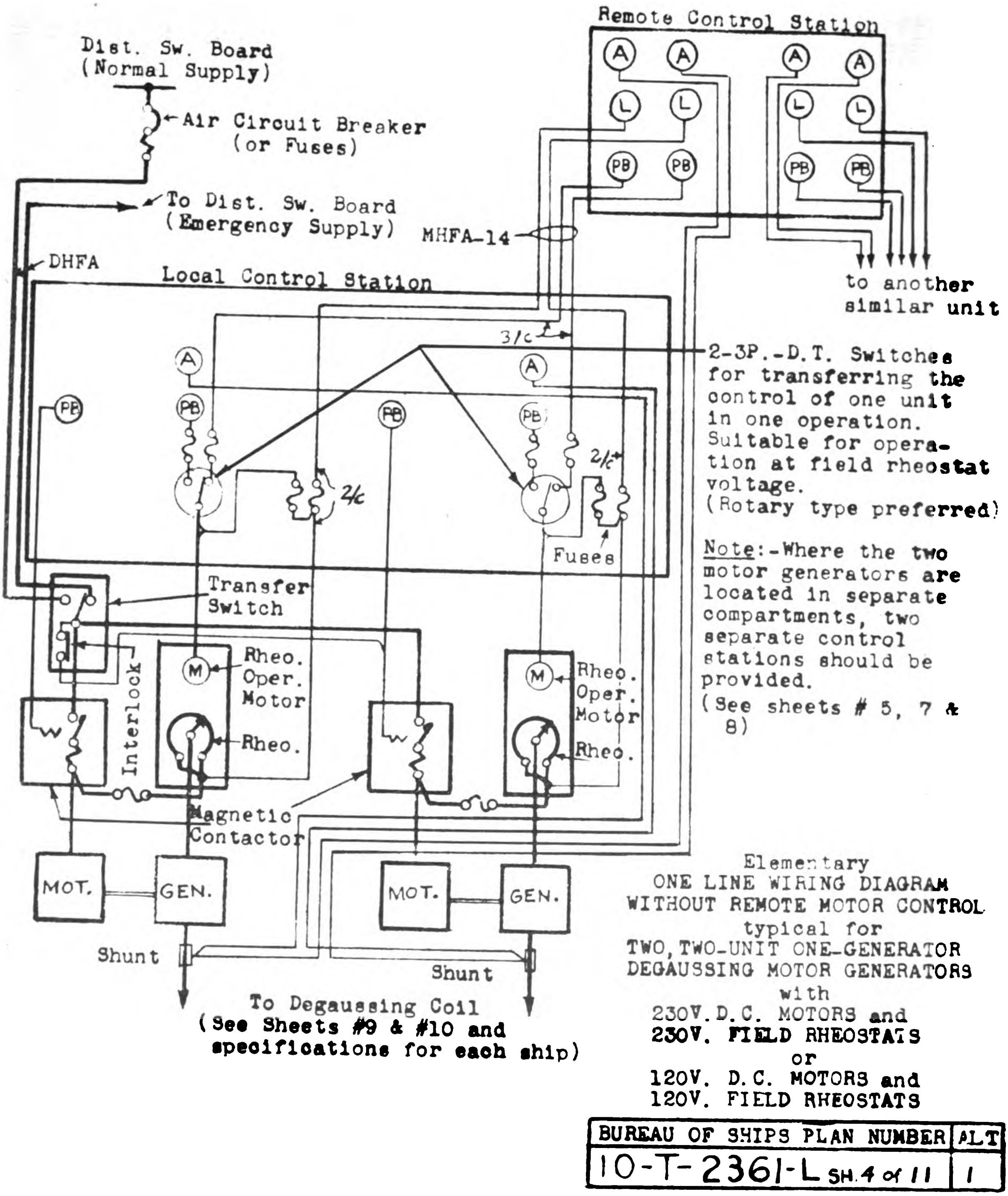
2-3P D.T. Switches for transferring the control of one unit in one operation. Suitable for operation at field rheostat voltage. Rotary type preferred.

Note:-Where the two motor generators are located in separate compartments two separate control stations should be provided. (See Sheets # 5 & # 6)

(See Sheets #9 & #10 and specifications for each ship)

Elementary
ONE LINE WIRING DIAGRAM
WITHOUT REMOTE MOTOR CONTROL
typical for
TWO, THREE-UNIT ONE-GENERATOR
DEGAUSSING MOTOR GENERATORS
with
440V. or 220V. 3Ø A.C. MOTORS

BUREAU OF SHIPS PLAN NUMBER	ALT.
10-1-2361-L SH.3 of 11	1



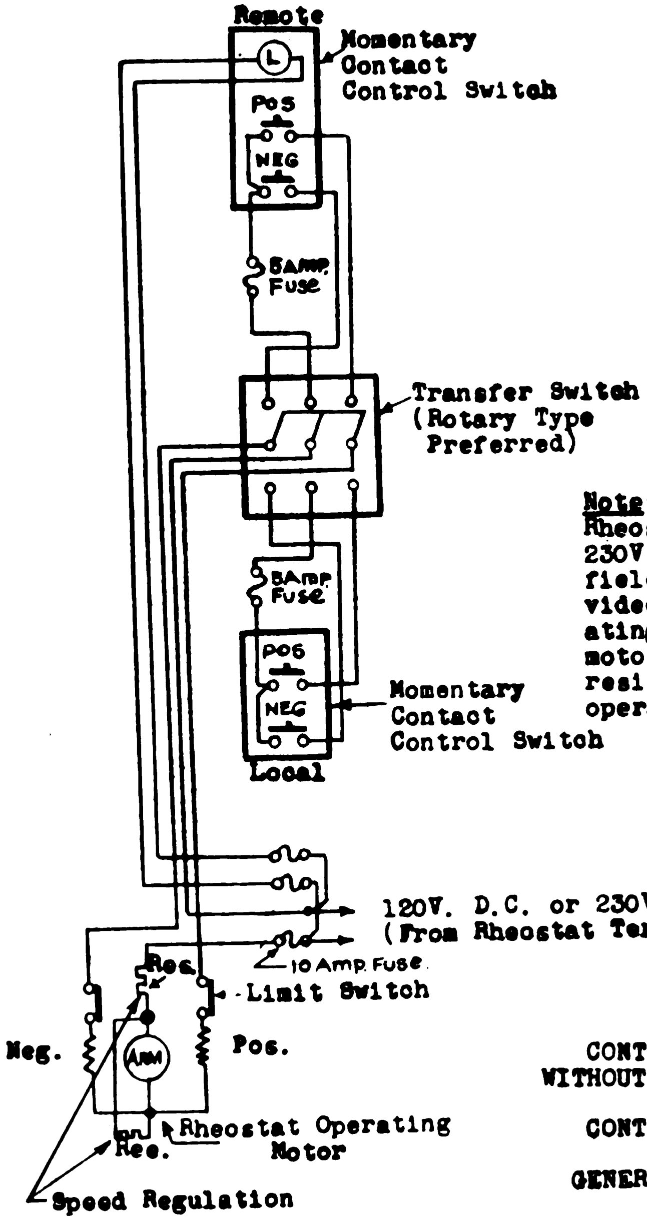
2-3P.-D.T. Switches for transferring the control of one unit in one operation. Suitable for operation at field rheostat voltage. (Rotary type preferred)

Note:-Where the two motor generators are located in separate compartments, two separate control stations should be provided. (See sheets # 5, 7 & 8)

To Degaussing Coil (See Sheets #9 & #10 and specifications for each ship)

Elementary
ONE LINE WIRING DIAGRAM
WITHOUT REMOTE MOTOR CONTROL
typical for
TWO, TWO-UNIT ONE-GENERATOR
DEGAUSSING MOTOR GENERATORS
with
230V. D.C. MOTORS and
230V. FIELD RHEOSTATS
or
120V. D.C. MOTORS and
120V. FIELD RHEOSTATS

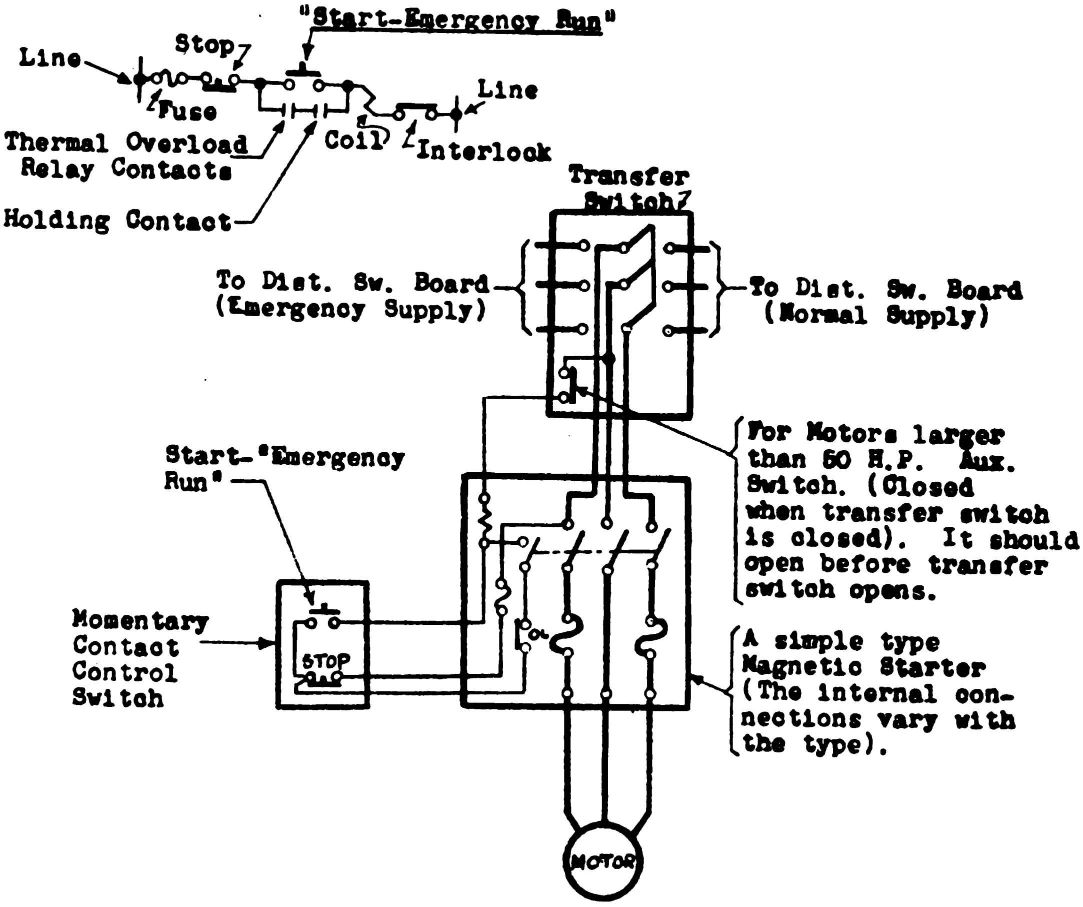
BUREAU OF SHIPS PLAN NUMBER	ALT
10-T-2361-L SH. 4 of 11	1



Note:
Rheostats designed for 230V. D.C. generator fields should be provided with 230V. operating motors or 125V. motors with suitable resistances to permit operation at 230V. D.C.

CONTROL WIRING DIAGRAM
WITHOUT REMOTE MOTOR CONTROL
with
CONTROL TRANSFER SWITCH
typical for
GENERATOR FIELD RHEOSTAT
for
DEGAUSSING MOTOR GENERATOR
with
230V. or 120V. GENERATOR FIELD

BUREAU OF SHIPS PLAN NUMBER	ALT.
10-T-2361-L SH. 5 of 11	1

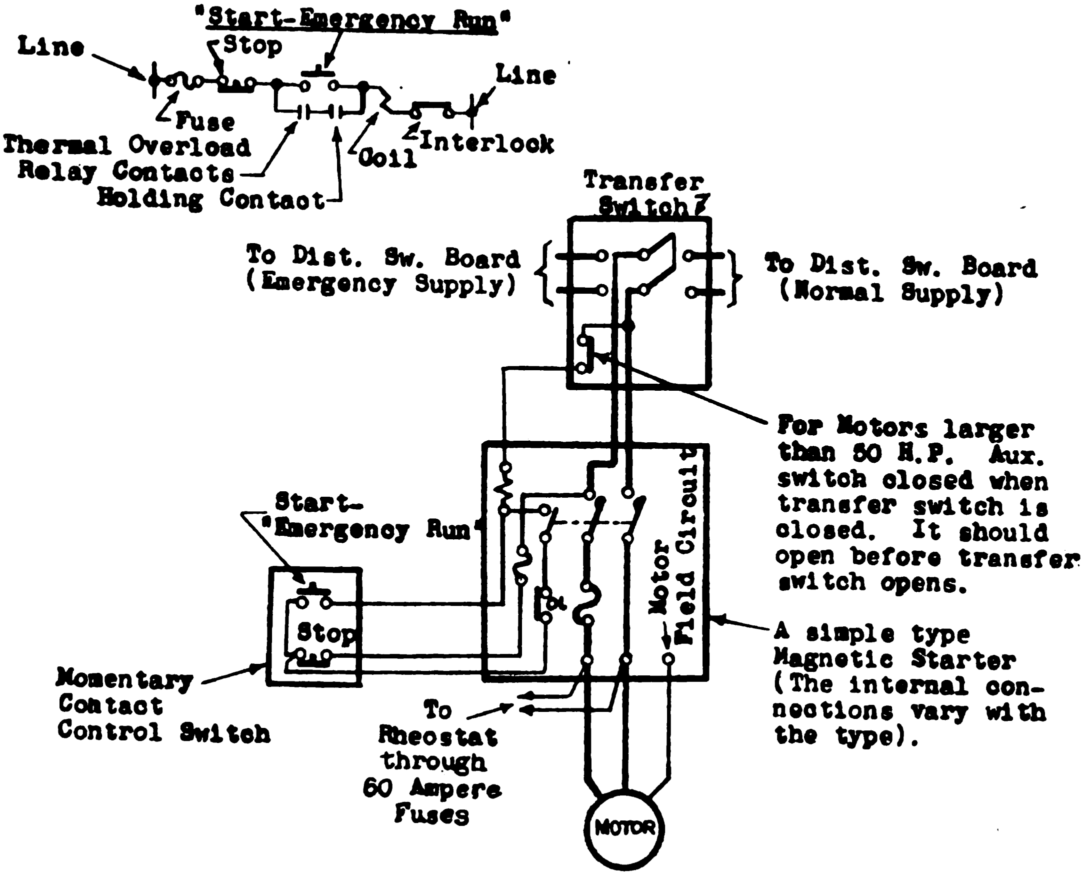

"Start-Emergency Run"
Line
Stop
Line
Fuse
Thermal Overload Relay Contacts
Coil
Interlock
Holding Contact
Transfer Switch
To Dist. Sw. Board (Emergency Supply)
To Dist. Sw. Board (Normal Supply)
For Motors larger than 50 H.P. Aux. Switch. (Closed when transfer switch is closed). It should open before transfer switch opens.
Start-"Emergency Run"
Momentary Contact Control Switch
STOP
OL
A simple type Magnetic Starter (The internal connections vary with the type).
MOTOR

Notes:

The starter may be held closed against overload and shock by keeping the "start-emergency run" push-button depressed.

CONTROL WIRING DIAGRAM
WITHOUT REMOTE MOTOR CONTROL
and without
CONTROL TRANSFER SWITCH
typical for MOTOR of
DEGAUSSING MOTOR GENERATOR
with
440V. or 220V. - 3 PHASE A.C. MOTOR
and DIRECT CONNECTED EXCITER

BUREAU OF SHIPS PLAN NUMBER	ALT
10-T-2361-L SH.6 of 11	1


"Start-Emergency Run"
Stop
Line
Line
Fuse
Thermal Overload Relay Contacts
Holding Contact
Coil
Interlock
Transfer Switch
To Dist. Sw. Board (Emergency Supply)
To Dist. Sw. Board (Normal Supply)
Start-"Emergency Run"
Stop
Motor Field Circuit
Momentary Contact Control Switch
To Rheostat through 60 Ampere Fuses
MOTOR

For Motors larger than 50 H.P. Aux. switch closed when transfer switch is closed. It should open before transfer switch opens.

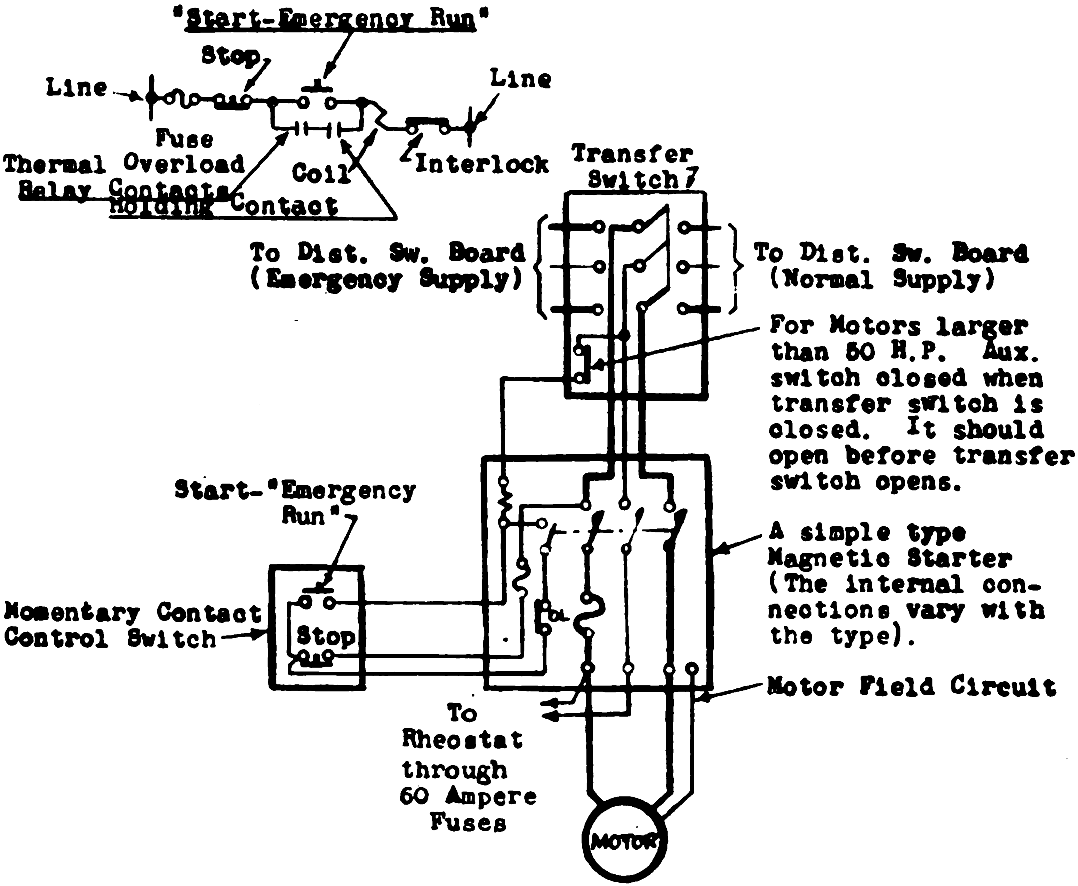
A simple type Magnetic Starter (The internal connections vary with the type).

Note:

The starter may be held closed against overload and shock by keeping the "start-emergency run" pushbutton depressed.

CONTROL WIRING DIAGRAM
WITHOUT REMOTE MOTOR CONTROL
and without
CONTROL TRANSFER SWITCH
typical for MOTOR of
DEGAUSSING MOTOR GENERATOR
with
230V. D.C. MOTOR and
230V. GENERATOR FIELD RHEOSTATS
or
120V. D.C. MOTOR and
120V. GENERATOR FIELD RHEOSTATS

BUREAU OF SHIPS PLAN NUMBER	ALT
10-T-2361-L SH.7 of 11.	1


"Start-Emergency Run"
Stop
Line
Line
Fuse
Thermal Overload Relay Contacts
Coil
Interlock
Holding Contact
Transfer Switch
To Dist. Sw. Board (Emergency Supply)
To Dist. Sw. Board (Normal Supply)
For Motors larger than 50 H.P. Aux. switch closed when transfer switch is closed. It should open before transfer switch opens.
Start-"Emergency Run"
Momentary Contact Control Switch
Stop
OL
A simple type Magnetic Starter (The internal connections vary with the type).
Motor Field Circuit
To Rheostat through 60 Ampere Fuses
MOTOR

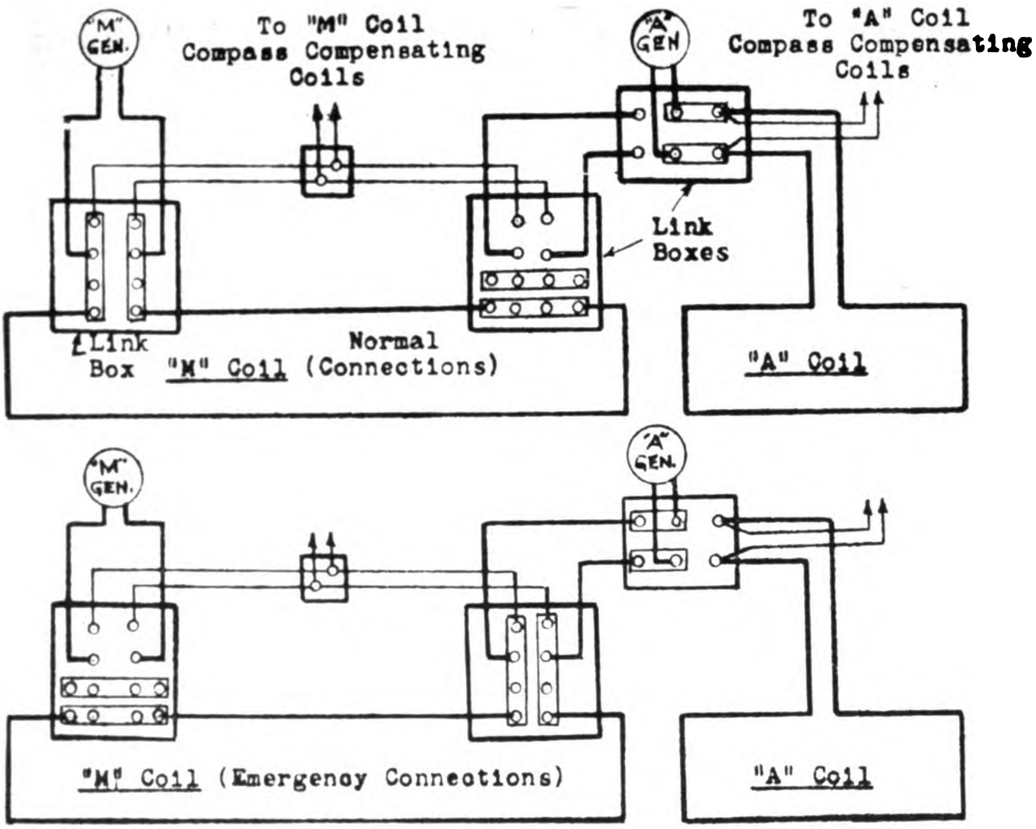
Note:

1. The starter may be held closed against overload and shock by keeping the "start-emergency run" pushbutton depressed.

2. It should be noted that the third leg can be omitted in the feeder cable, motor starter and transfer switch if the generator is equipped with 230V. field rheostat and rheostat operating motor.

CONTROL WIRING DIAGRAM
WITHOUT REMOTE MOTOR CONTROL
and without
CONTROL TRANSFER SWITCH
typical for
MOTOR of
DEGAUSSING MOTOR GENERATOR
with
230V. D.C. MOTOR and
120V. GENERATOR FIELD RHEOSTATS

BUREAU OF SHIPS PLAN NUMBER	ALT.
10-T-2361-L SH 8 of 11	1



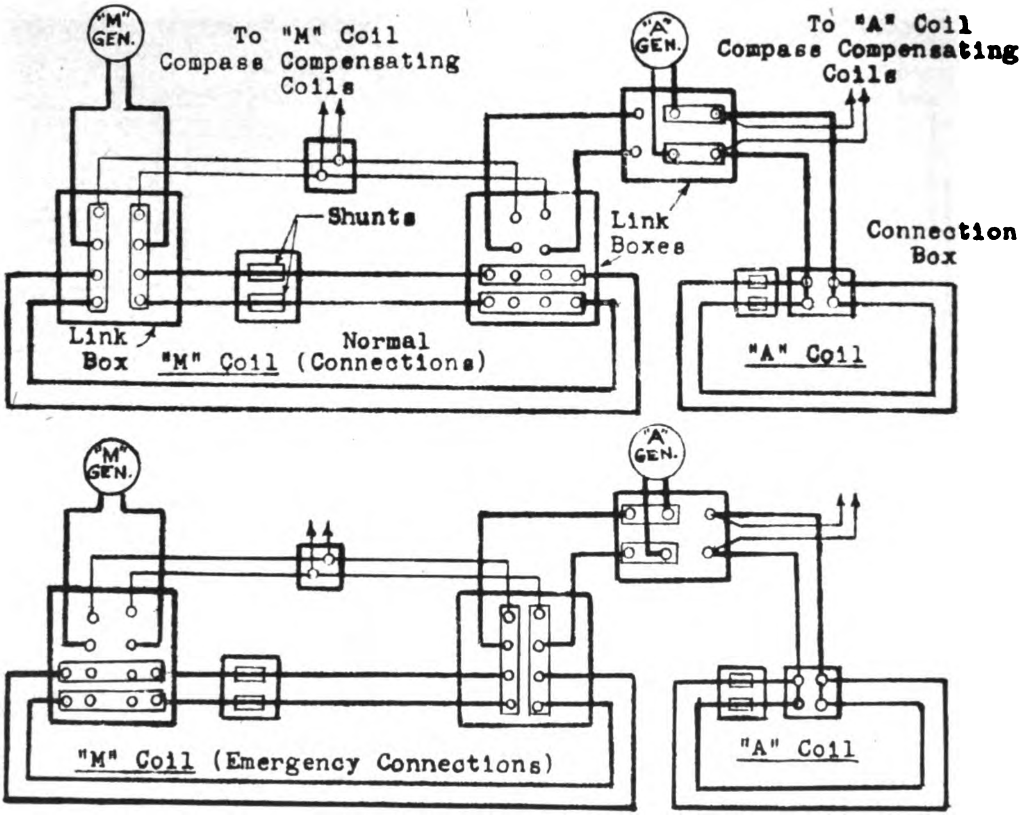
INSTRUCTIONS
IN THE EVENT OF CASUALTY TO THE "M" COIL GENERATOR

1. Adjust current in the "M" coil to zero.
2. Shut down the "M" coil generator set.
3. Adjust the current in the "A" coil to zero.
4. Shut down the "A" coil motor generator set.
5. Move the links to the emergency positions.
6. The "A" coil generator is then connected to supply current to the "M" coil and the "A" coil is inoperative.
7. Start up motor generator sets and adjust the currents in the coils to the desired values.
8. The current in the "M" coil will now be indicated on the "A" coil ammeter and will be controlled by the "A" coil pushbutton.

Instructions similar to the above should be placed at each of the remote and local control stations.

WIRING DIAGRAM
typical for
DEGAUSSING MOTOR GENERATOR CONNECTIONS to
"M" COIL WITH ONE SERIES CIRCUIT
and
"A" COIL WITH ONE SERIES CIRCUIT

BUREAU OF SHIPS PLAN NUMBER	Alt.
10-T-2361-L SH.9 of 11	1



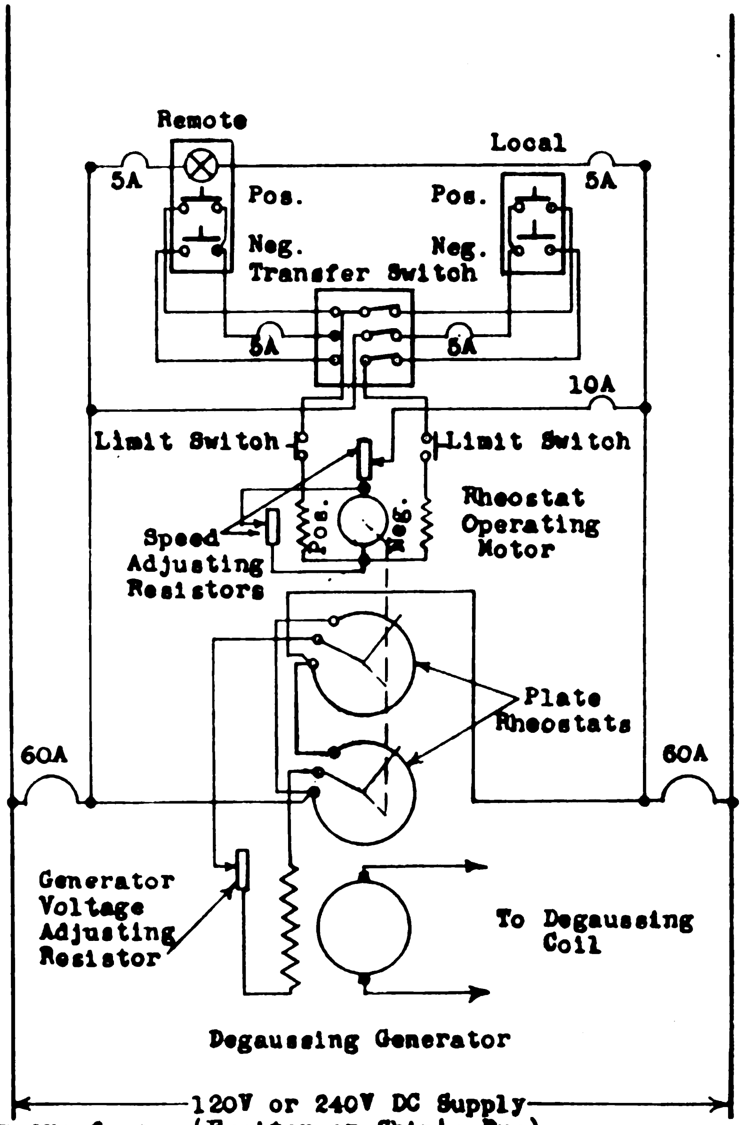
INSTRUCTIONS
IN THE EVENT OF CASUALTY TO THE "M" COIL GENERATOR

1. Adjust current in the "M" coil to zero.
2. Shut down the "M" coil generator set.
3. Adjust the current in the "A" coil to zero.
4. Shut down the "A" coil motor generator set.
5. Move the links to the emergency positions.
6. The "A" coil generator is then connected to supply current to the "M" coil and the "A" coil is inoperative.
7. Start up motor generator sets and adjust the currents in the coils to the desired values.
8. The current in the "M" coil will now be indicated on the "A" coil ammeter and will be controlled by the "A" coil pushbutton.

Instructions similar to the above should be placed at each of the remote and local control stations

WIRING DIAGRAM
typical for
DEGAUSSING MOTOR GENERATOR CONNECTIONS
to
"M" COIL WITH TWO PARALLEL CIRCUITS
and
"A" COIL WITH TWO PARALLEL CIRCUITS

BUREAU OF SHIPS PLAN NUMBER	Alt.
10-T-2361-L SH.10of11	1

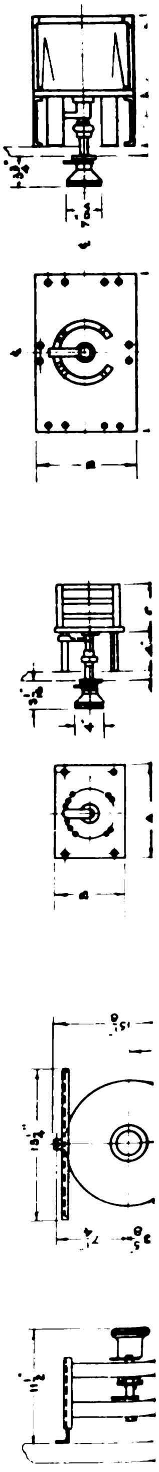


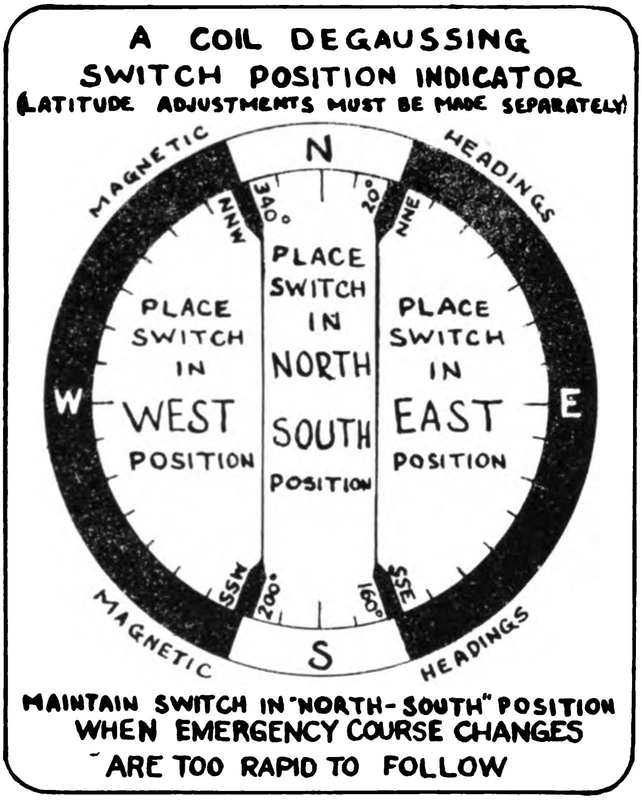
Notes:

1. The 60 ampere fuses are used only when the source of supply is taken from the Ship's Bus. Exciters should be direct connected to the rheostat terminals.
2. Rheostats designed for 230V DC generator fields should be provided with 230V operating motors or 125V motors with suitable resistances to permit operation at 230V DC.

SCHEMATIC WIRING DIAGRAM
for Control of
Generator Field of
Degaussing Motor Generator

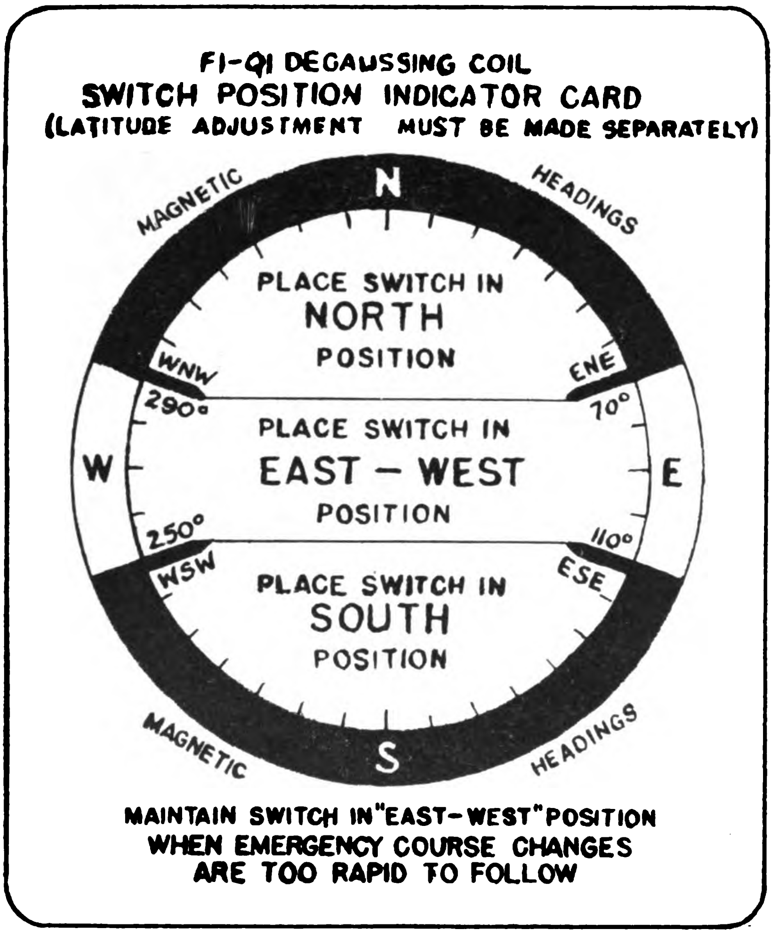
Bureau of Ships Plan Number	ALT
10-T-2361-L SH.11 of 11	0




A COIL DEGAUSSING
SWITCH POSITION INDICATOR
(LATITUDE ADJUSTMENTS MUST BE MADE SEPARATELY)
MAGNETIC
HEADINGS
N
340°
20°
NNW
NNE
PLACE SWITCH IN NORTH SOUTH POSITION
PLACE SWITCH IN WEST POSITION
PLACE SWITCH IN EAST POSITION
W
E
SSW
SSE
200°
160°
S
MAGNETIC
HEADINGS
MAINTAIN SWITCH IN "NORTH-SOUTH" POSITION
WHEN EMERGENCY COURSE CHANGES
ARE TOO RAPID TO FOLLOW

BUREAU OF SHIPS NAVY DEPT. WASH., D.C.

	ALTERATION	INDEX	GROUP	FILE NO.
1. 2.	ADDED COMPASS POINTS Changed lettering.	10	T	2703-L ALT. 2



(APPROXIMATELY FULL SIZE)

FI-QI COIL
DEGAUSSING INSTALLATION
SWITCH POSITION INDICATOR
CARD

BUREAU OF SHIPS NAVY DEPT. WASH. D.C.

ALTERATION	INDEX	GROUP	FILE NO.
1. ADDED COMPASS POINTS. 2. CHANGED LETTERING	10	T	2702-L ALT. 2

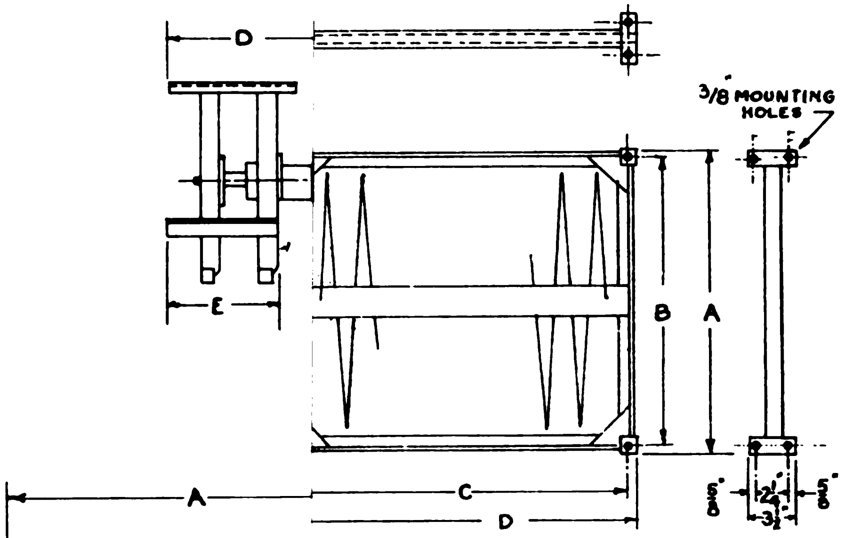
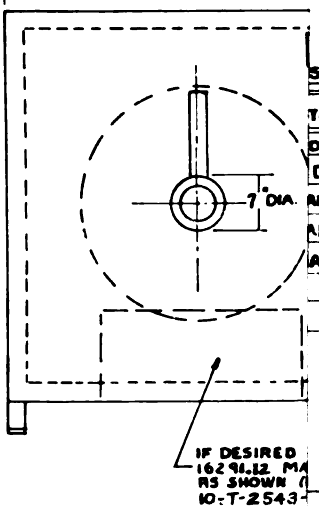


FIG. 3



IF DESIRED
16291.12 MA
AS SHOWN (
10-T-2543-

S

TANCE ELEMENT	MOUNTING DIMENSIONS FOR FIG	A	B	C	D	WT.
D. RIBFLEX IN SERIES	2	2 1/2	—	—	—	3#
D RIBFLEX IN SERIES	2	5 1/2	—	—	—	4
AROHM	3	18	16 7/8	13 3/8	14 1/2	6 1/4
AROHM	3	18	16 7/8	13 3/8	14 1/2	6 1/4
AROHM	3	18	16 7/8	22 3/8	23 1/2	11

O.	DESCRIPTION	DATE
1	ADDED SPARE PARTS & ADD. CONTRACTS	7/10/44

ALTERATIONS

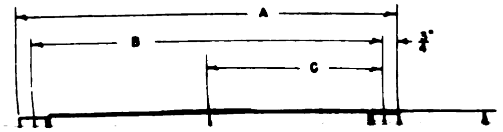
CLASSIFICATION NUMBER
5230
5360
53120
5108
5115

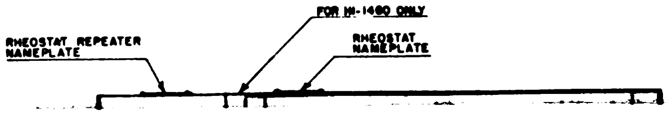
240 V. D.C.

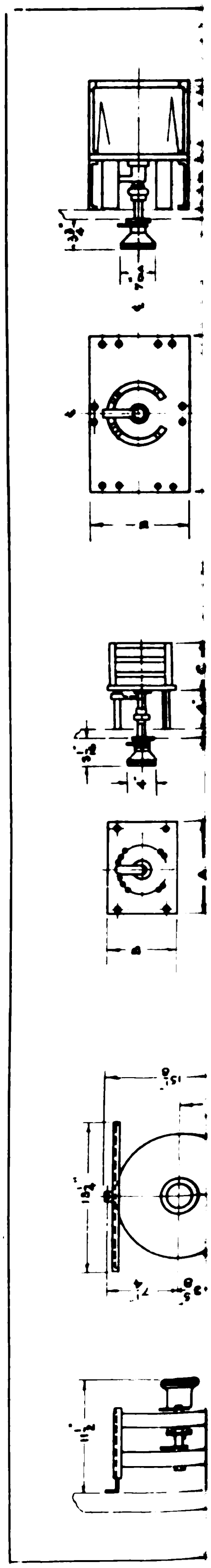
DIMENSIONS FOR DEGAUSSING CONTROL RHEOSTATS & RESISTORS

NAVY DEPT.
BUREAU OF SHIPS
WASHINGTON, D.C.
AUG 1, 1942

INDEX	GROUP	FILE NUMBER
10	T	2544-L-ALT. 1


A
B
C
3/4"


RHEOSTAT REPEATER NAMEPLATE
FOR M-1480 ONLY
RHEOSTAT NAMEPLATE



A MFR'S NAME WARD LEONARD ELECTRI
B THE EQUIPMENT SHOWN ON THIS PLAN IS
SPECIFICATION 17R4 a

C EXCEPTION TO N.D. SPEC. 17R4 AND
NONE (SEE SEC.

D DESCRIPTIVE DATA OF RESISTOR
1 TYPE - FIXED WITH TAPS
2 ENCLOSURE - OPEN
3 RATING - VOLTS - 300 - MAX

TYPE	RESISTANCE IN OHMS	CA IN
45FI	1.0	
90FI	0.5	
130FI	0.36	
210FI	0.21	

4 DUTY - CONTINUO
5 ADJUSTABILITY - STEP BY
6 MOUNTING - MOUNTING
7 SERVICE - CLASS A
8 AMBIENT - 50°C
9 INSULATION - CLASS C

E WEIGHTS

1 COMPLETE UNIT

ASSEMBLY NO	TYPE NO
17227-1	45FI
17227-2	90FI OR 130FI
17227-3	210FI

F NOTES

1 FOR TYPE NUMBER FURNISHED
SEE CERTIFICATION DATA SHE

2 RESISTOR UNITS SHOWN ON TH
SAMPLE BY EXTENSION OF MOUN
TERMINAL PANEL

3 ON -2, FOR 90 AMP UNIT SUPPL
FOR 130 AMP UNIT SUPPLY (1) TER

4 MOUNTING BRACKETS ARE REN
ONE COAT OF ZINC CHROMATE
BY ONE COAT OF DULL BLACK A

MATERIAL

FOR ONE ASSEMBLY

D	MATL	MATL SPEC.	MFR'S INFO	REMARKS
3	ASSEM	17R4	20459	
1	STEEL	47S11	20459.1	SEE NOTE F4
1	STEEL	47S11	20459 2	SEE NOTE F4
4	STEEL	47S11	20459 1-12	SEE NOTE F4
	[illegible] PLATE	17P25	20459 3-1	SEE NOTE F-3 TYPE AAA
1	[illegible] PLATE	17P25	20459.4-1	SEE NOTE F-3 TYPE AAA
1	BRASS	47B2	3691.13-1	CHROME PL

VAL STATUS

RECORD PLANS		BUREAU APPROVAL
BU. SHIPS	BU. ORD	LETTER DATE
		S62-2-(7)(660 4-330) 20 MAR 1949
*	*	

OR GENERAL DISTRIBUTION

TABLE OF ALTERATIONS

	DESCRIPTION	AUTH. BY	[illegible] DATE	APP.	[illegible] DATE	APP.

WARD LEONARD
ELECTRIC CO.
MOUNT VERNON, NEW YORK, U.S.

WARD LEONARD ELECTRIC CO. PLAN NO. 17227

SCALE AS NOTED DRAWN BY DATE 8-31-49
TRACED BY CHECKED BY APPROVED BY R.C.
APPROVED BY

APPROVED BY BUSHIPS LETTER NObs - 47788 (660M)
OVER SER. 660-34950 OF 23 FEB 1950
SIGNED BY DATE
TITLE

MASTER PLAN

TYPE	45FI	1.0 OHM	45 AMP
TYPE	90FI	0.5 OHM	90 AMP
TYPE	130FI	0.36 OHM	130 AMP
TYPE	210FI	0.21 OHM	210 AMP

DEGAUSSING RESISTOR

120 VOLTS D.C.

BUREAU OF SHIPS PLAN NUMBER
S6202-3,002,159 ALT. 0

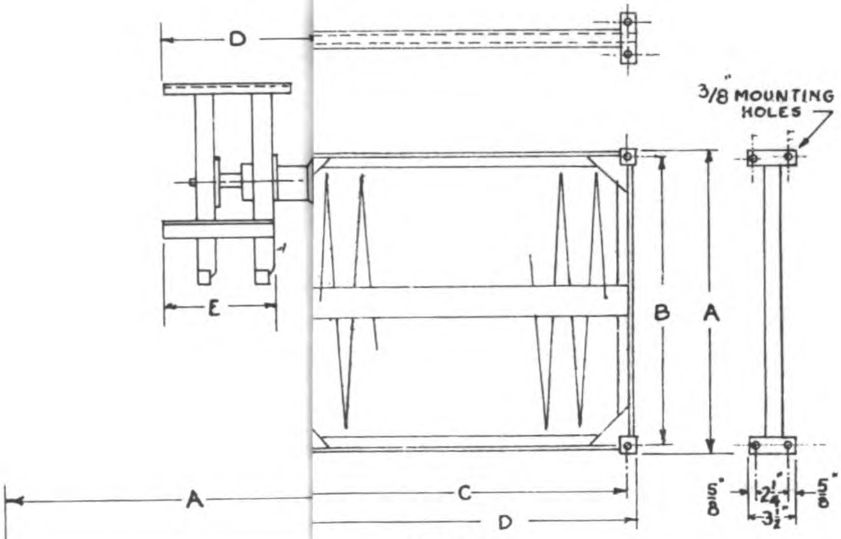
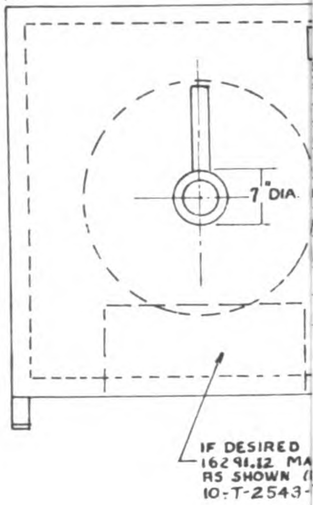


FIG. 3



S

TANCE ELEMENT	MOUNTING DIMENSIONS FOR FIG	A	B	C	D	WT.
O. RIBFLEX IN SERIES	2	$2\frac{1}{2}$	—	—	—	3#
D RIBFLEX IN SERIES	2	$5\frac{1}{2}$	—	—	—	4
AROHM	3	18	$16\frac{7}{8}$	$13\frac{3}{8}$	$14\frac{1}{2}$	$6\frac{1}{4}$
AROHM	3	18	$16\frac{7}{8}$	$13\frac{3}{8}$	$14\frac{1}{2}$	$6\frac{1}{4}$
AROHM	3	18	$16\frac{7}{8}$	$22\frac{3}{8}$	$23\frac{1}{2}$	11

CLASSIFICATION NUMBER
5230
5360
53120
5108
5115

1	ADDED SPARE PARTS & ADD. CONTRACTS	7/18/44
O.	DESCRIPTION	DATE

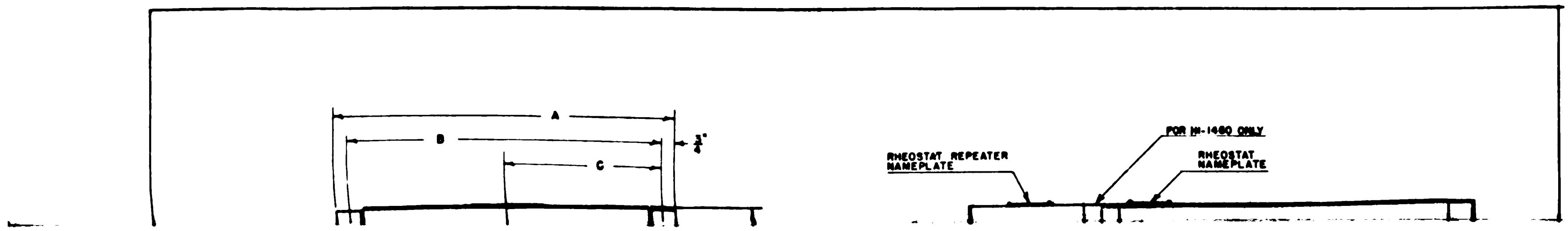
ALTERATIONS

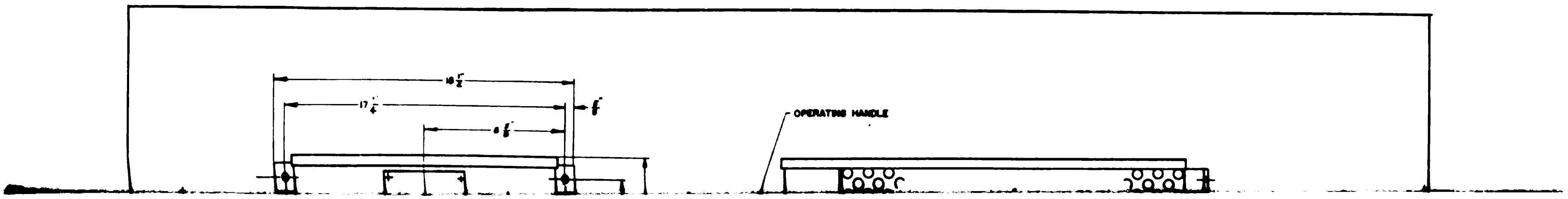
240 V. D.C.

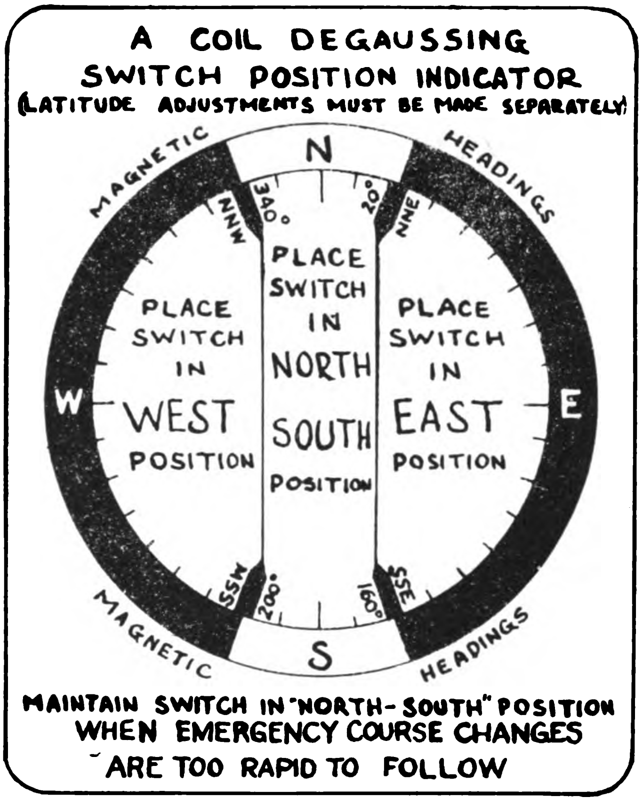
DIMENSIONS FOR DEGAUSSING CONTROL RHEOSTATS & RESISTORS

NAVY DEPT.
BUREAU OF SHIPS
WASHINGTON, D.C.
AUG 1, 1942

INDEX	GROUP	FILE NUMBER
10	T	2544-L-ALT. 1

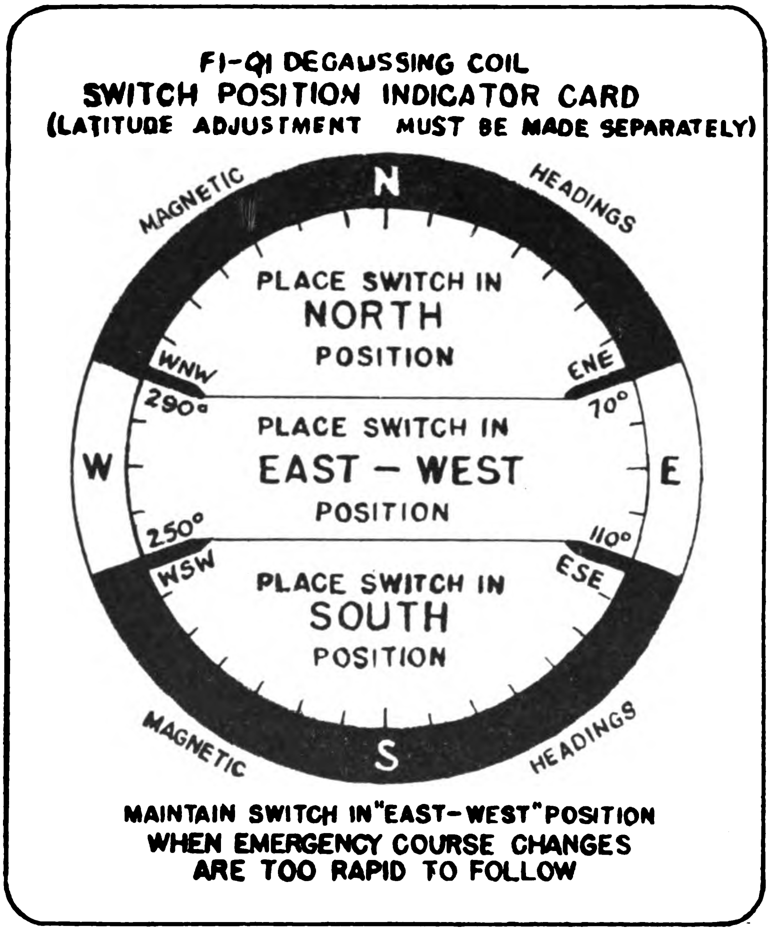

A
B
C
$\frac{3}{4}''$
RHEOSTAT REPEATER NAMEPLATE
FOR M-1480 ONLY
RHEOSTAT NAMEPLATE


18 1/2"
17 1/4"
8 5/8"
5/8"
OPERATING HANDLE


A COIL DEGAUSSING
SWITCH POSITION INDICATOR
(LATITUDE ADJUSTMENTS MUST BE MADE SEPARATELY)
MAGNETIC
N
HEADINGS
NNW
340°
20°
NNE
PLACE SWITCH IN NORTH SOUTH POSITION
PLACE SWITCH IN WEST POSITION
PLACE SWITCH IN EAST POSITION
W
E
SSW
200°
160°
SSE
MAGNETIC
S
HEADINGS
MAINTAIN SWITCH IN "NORTH-SOUTH" POSITION
WHEN EMERGENCY COURSE CHANGES
ARE TOO RAPID TO FOLLOW

BUREAU OF SHIPS NAVY DEPT. WASH., D.C.

ALTERATION	INDEX	GROUP	FILE NO.
1. ADDED COMPASS POINTS 2. Changed lettering.	10	T	2703-L ALT. 2



F1-Q1 DEGAUSSING COIL
SWITCH POSITION INDICATOR CARD
(LATITUDE ADJUSTMENT MUST BE MADE SEPARATELY)

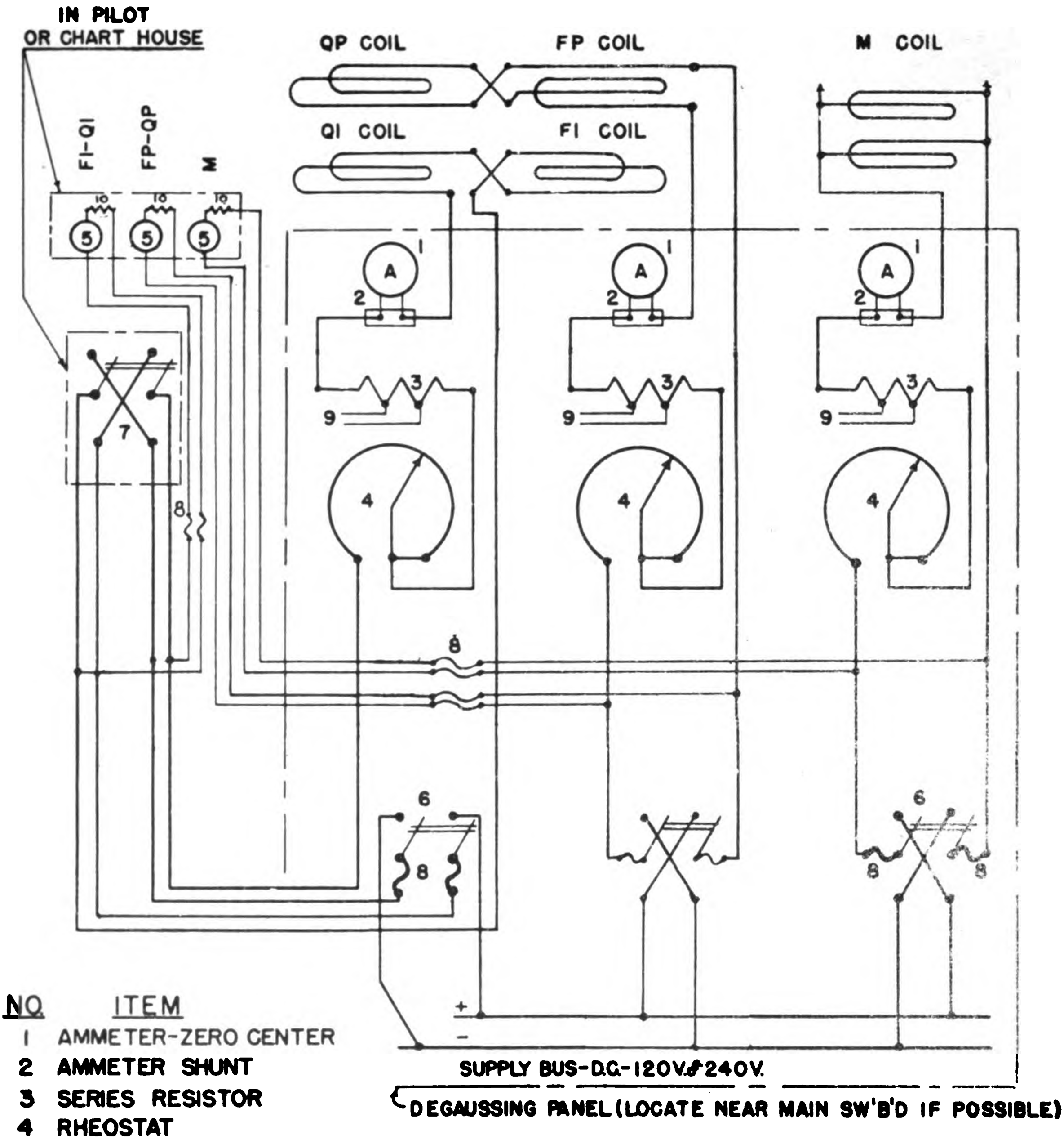
MAINTAIN SWITCH IN "EAST–WEST" POSITION
WHEN EMERGENCY COURSE CHANGES
ARE TOO RAPID TO FOLLOW

(APPROXIMATELY FULL SIZE)

F1-Q1 COIL
DEGAUSSING INSTALLATION
SWITCH POSITION INDICATOR CARD

BUREAU OF SHIPS NAVY DEPT. WASH. D.C.

ALTERATION	INDEX	GROUP	FILE NO.
1. ADDED COMPASS POINTS. 2. CHANGED LETTERING	10	T	2702-L ALT. 2

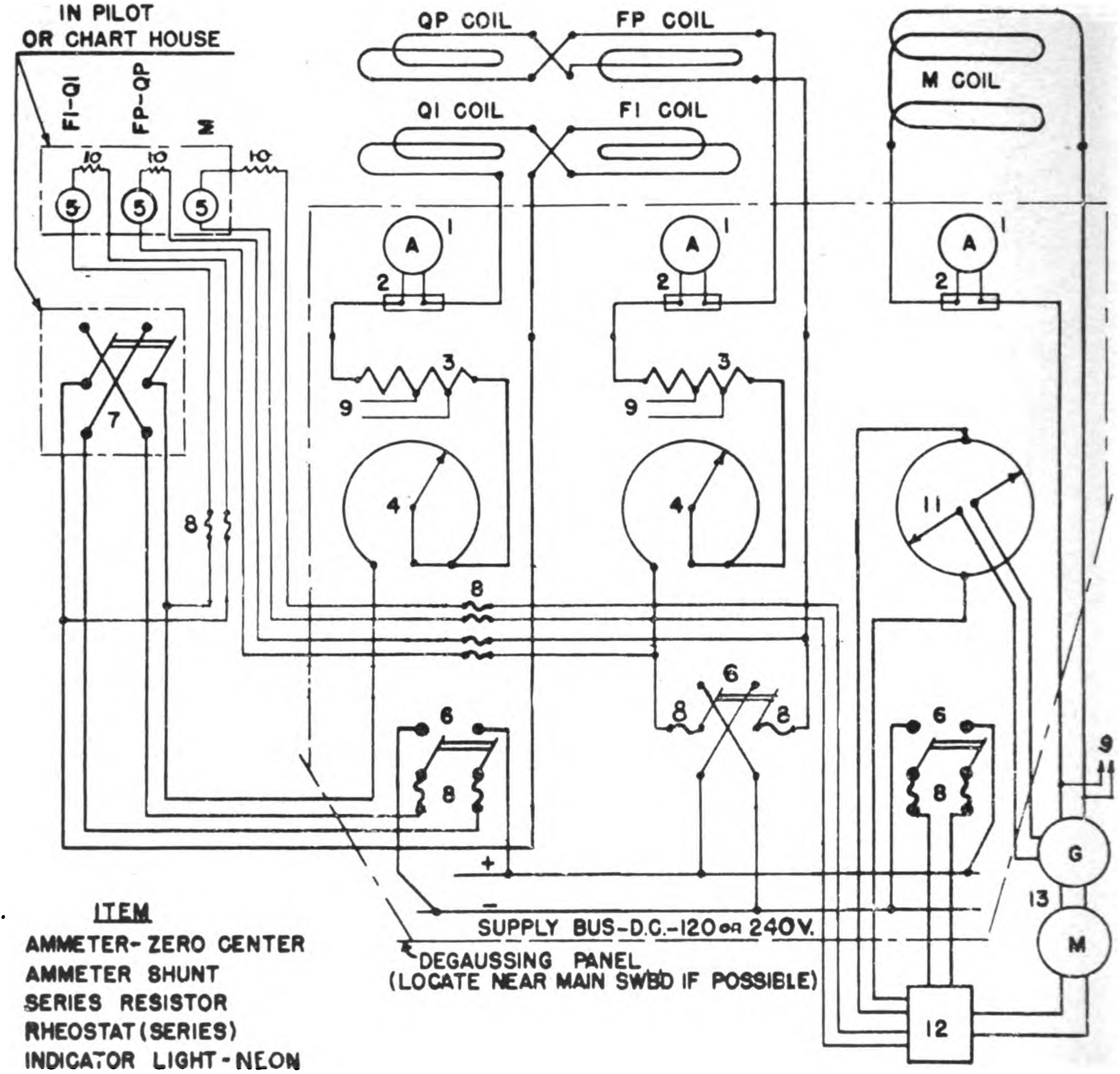

IN PILOT
OR CHART HOUSE
QP COIL
FP COIL
M COIL
QI COIL
FI COIL
FI-QI
FP-QP
M
10
5
A
1
2
3
4
6
7
8
9
+
−
SUPPLY BUS-D.C.-120V.&240V.
DEGAUSSING PANEL (LOCATE NEAR MAIN SW'B'D IF POSSIBLE)

NO.	ITEM
1	AMMETER-ZERO CENTER
2	AMMETER SHUNT
3	SERIES RESISTOR
4	RHEOSTAT
5	INDICATOR LIGHT-NEON
6	SUPPLY SWITCH
7	HEADING CONTROL SWITCH
8	FUSES
9	COMPASS COMP. COIL LEADS
10	LAMP RESISTOR

SPLIT-COIL SYSTEM
DEGAUSSING INSTALLATION
ELEMENTARY WIRING DIAGRAM

BUSHIPS NAVY DEPT. WASH. D.C. 10/7/42

ALTERATIONS		INDEX	GROUP	FILE NO.
OMIT COIL DETAILS. RELOCATE INDICATOR LIGHT LEADS REMOVE DISCHRG. RES.	CHANGED P COIL SWITCH FROM DPST TO DPDT	10	T	2701-L ALT. 4

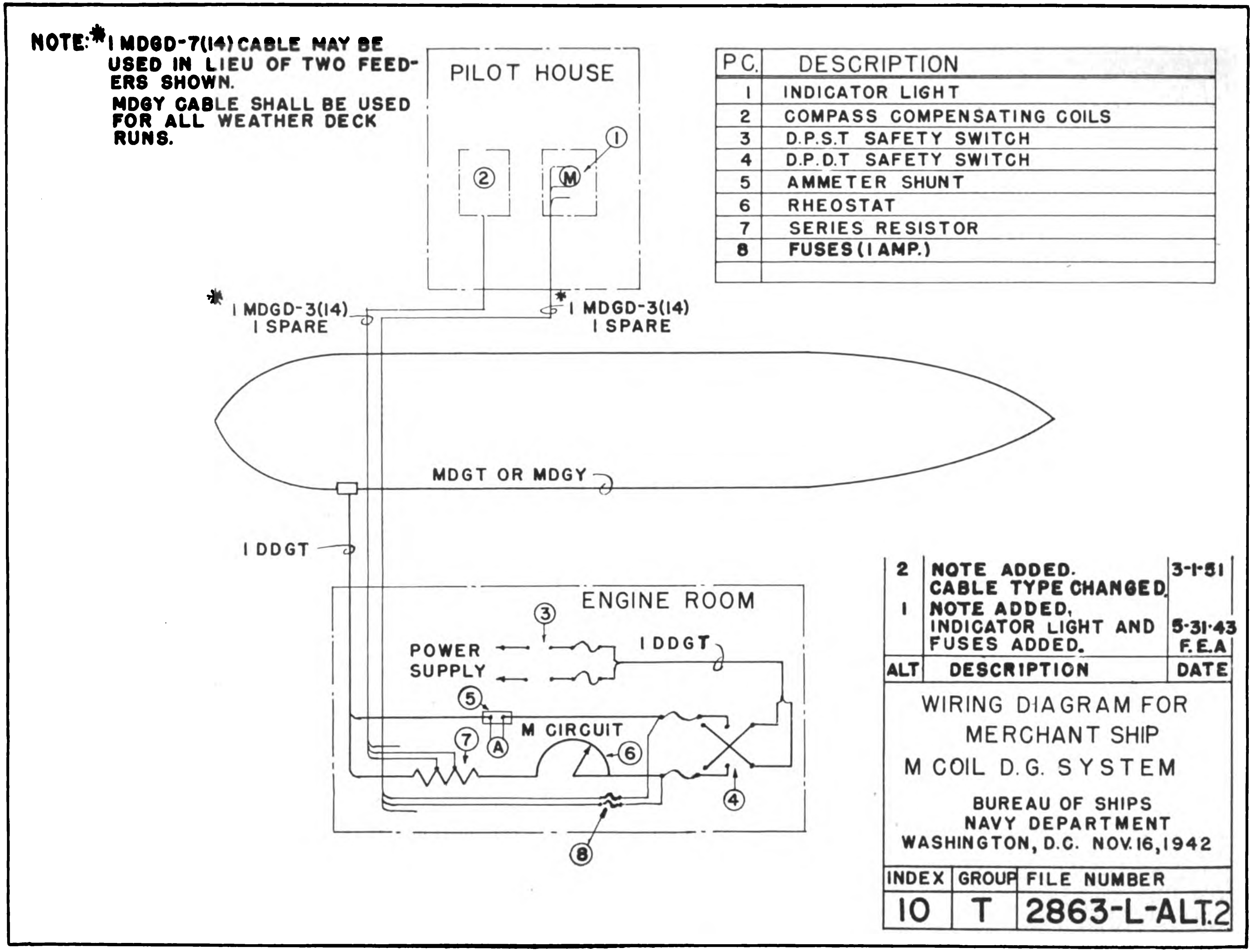


NO.	ITEM
1	AMMETER-ZERO CENTER
2	AMMETER SHUNT
3	SERIES RESISTOR
4	RHEOSTAT (SERIES)
5	INDICATOR LIGHT-NEON
6	SUPPLY SWITCH
7	HEADING CONTROL SWITCH
8	FUSES
9	COMPASS COMP. COIL LEADS
10	LAMP RESISTOR
11	RHEOSTAT (GEN. FIELD)
12	MOTOR CONTROLLER
13	MOTOR-GENERATOR

SPLIT-COIL SYSTEM
DEGAUSSING INSTALLATION
ELEMENTARY WIRING DIAGRAM
(M-G SET AND SINGLE COND. CABLE FOR "M" COIL)

BUSHIPS NAVY DEPT. WASH., D.C. 11/24/42

ALTERATIONS		INDEX	GROUP	FILE NO.
1 MODIFED INDICATOR LIGHTS & ELIMINATED DISCHARGE RESISTORS	2. CHANGED P COIL SWITCH FROM DPST TO DPDT	10	T	2873-L ALT. 2



NOTE: *I MDGD-7(14) CABLE MAY BE USED IN LIEU OF TWO FEEDERS SHOWN.

MDGY CABLE SHALL BE USED FOR ALL WEATHER DECK RUNS.

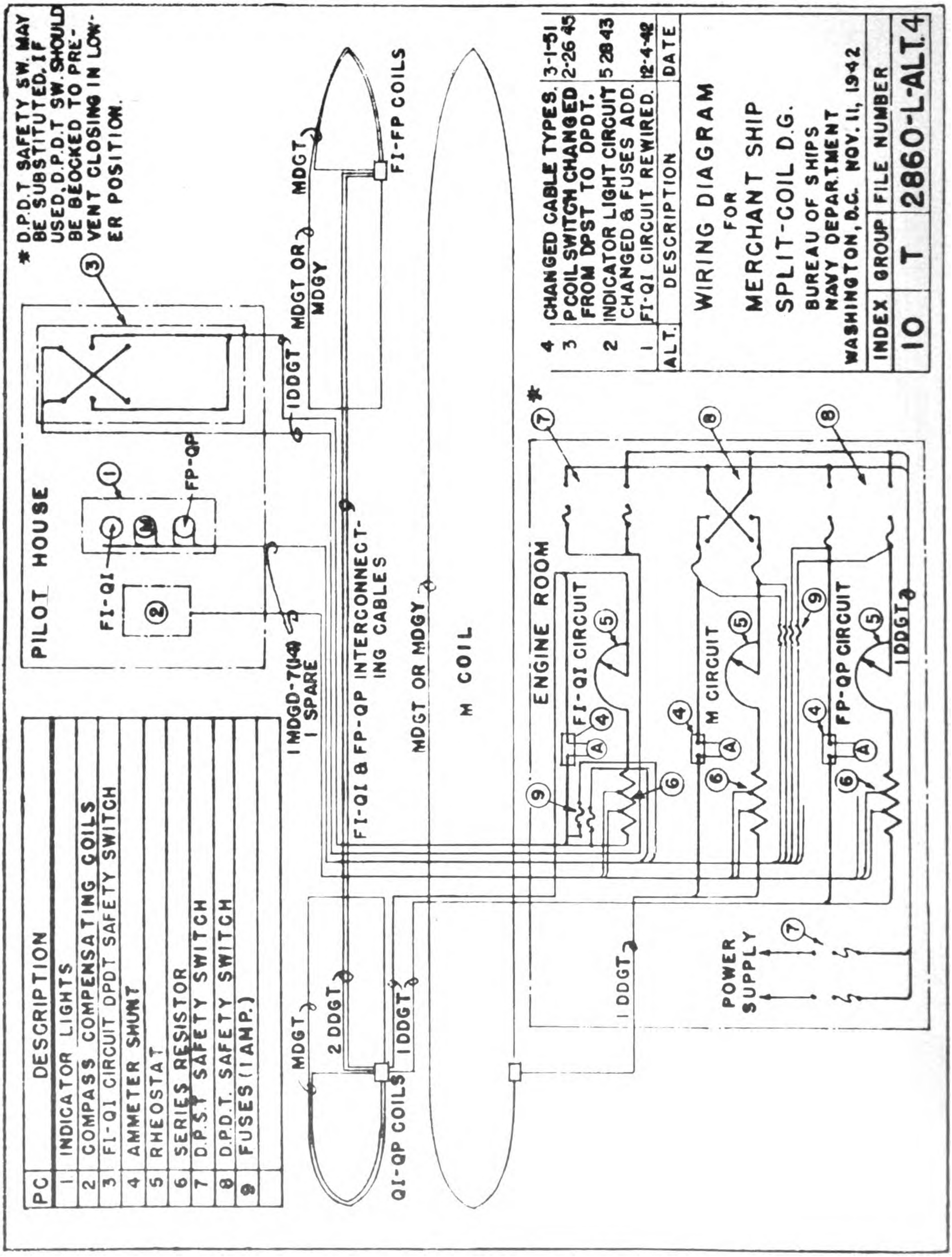
P.C.	DESCRIPTION
1	INDICATOR LIGHT
2	COMPASS COMPENSATING COILS
3	D.P.S.T SAFETY SWITCH
4	D.P.D.T SAFETY SWITCH
5	AMMETER SHUNT
6	RHEOSTAT
7	SERIES RESISTOR
8	FUSES (I AMP.)

ALT	DESCRIPTION	DATE
2	NOTE ADDED. CABLE TYPE CHANGED.	3-1-51
1	NOTE ADDED, INDICATOR LIGHT AND FUSES ADDED.	5-31-43 F.E.A

WIRING DIAGRAM FOR
MERCHANT SHIP
M COIL D.G. SYSTEM

BUREAU OF SHIPS
NAVY DEPARTMENT
WASHINGTON, D.C. NOV. 16, 1942

INDEX	GROUP	FILE NUMBER
10	T	2863-L-ALT.2



* D.P.D.T. SAFETY SW. MAY BE SUBSTITUTED. IF USED, D.P.D.T SW. SHOULD BE BLOCKED TO PREVENT CLOSING IN LOWER POSITION.

PC	DESCRIPTION
1	INDICATOR LIGHTS
2	COMPASS COMPENSATING COILS
3	FI-QI CIRCUIT DPDT SAFETY SWITCH
4	AMMETER SHUNT
5	RHEOSTAT
6	SERIES RESISTOR
7	D.P.S.T SAFETY SWITCH
8	D.P.D.T. SAFETY SWITCH
9	FUSES (1 AMP.)

ALT.	DESCRIPTION	DATE
4	CHANGED CABLE TYPES.	3-1-51
3	P COIL SWITCH CHANGED FROM DPST TO DPDT.	2-26-45
2	INDICATOR LIGHT CIRCUIT CHANGED & FUSES ADD.	5-28-43
1	FI-QI CIRCUIT REWIRED.	12-4-42

WIRING DIAGRAM
FOR
MERCHANT SHIP
SPLIT-COIL D.G.
BUREAU OF SHIPS
NAVY DEPARTMENT
WASHINGTON, D.C. NOV. 11, 1942

INDEX	GROUP	FILE NUMBER
10	T	2860-L-ALT.4

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